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MACHINE DESIGN

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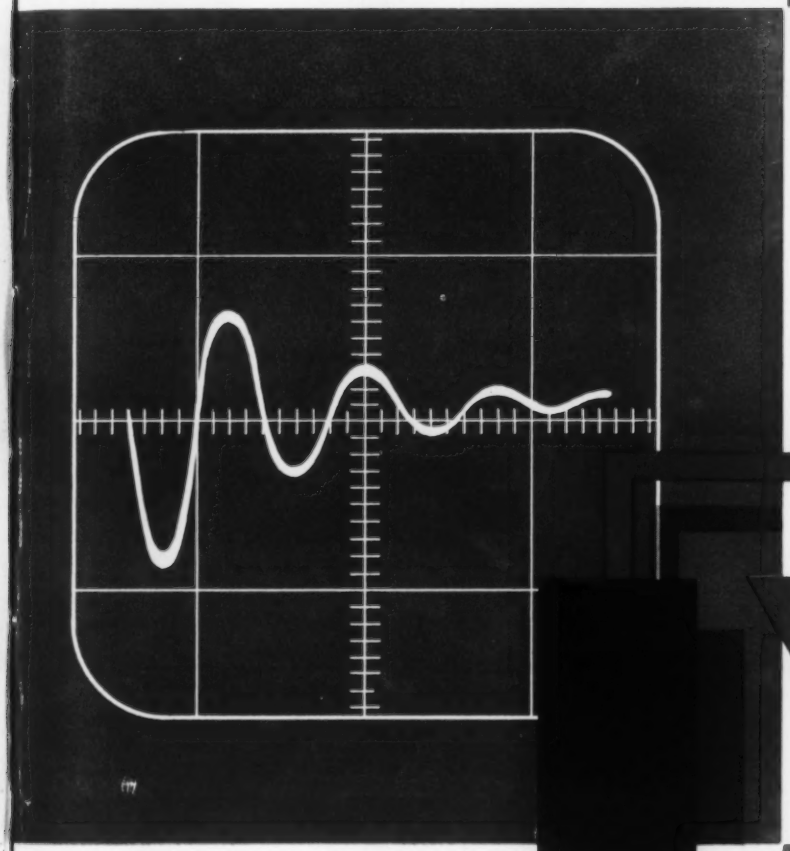

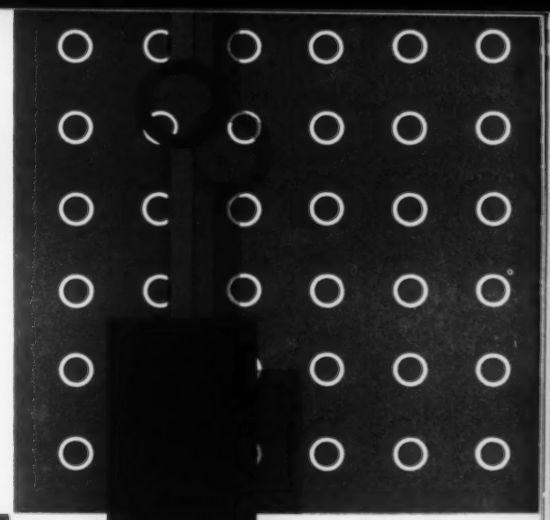

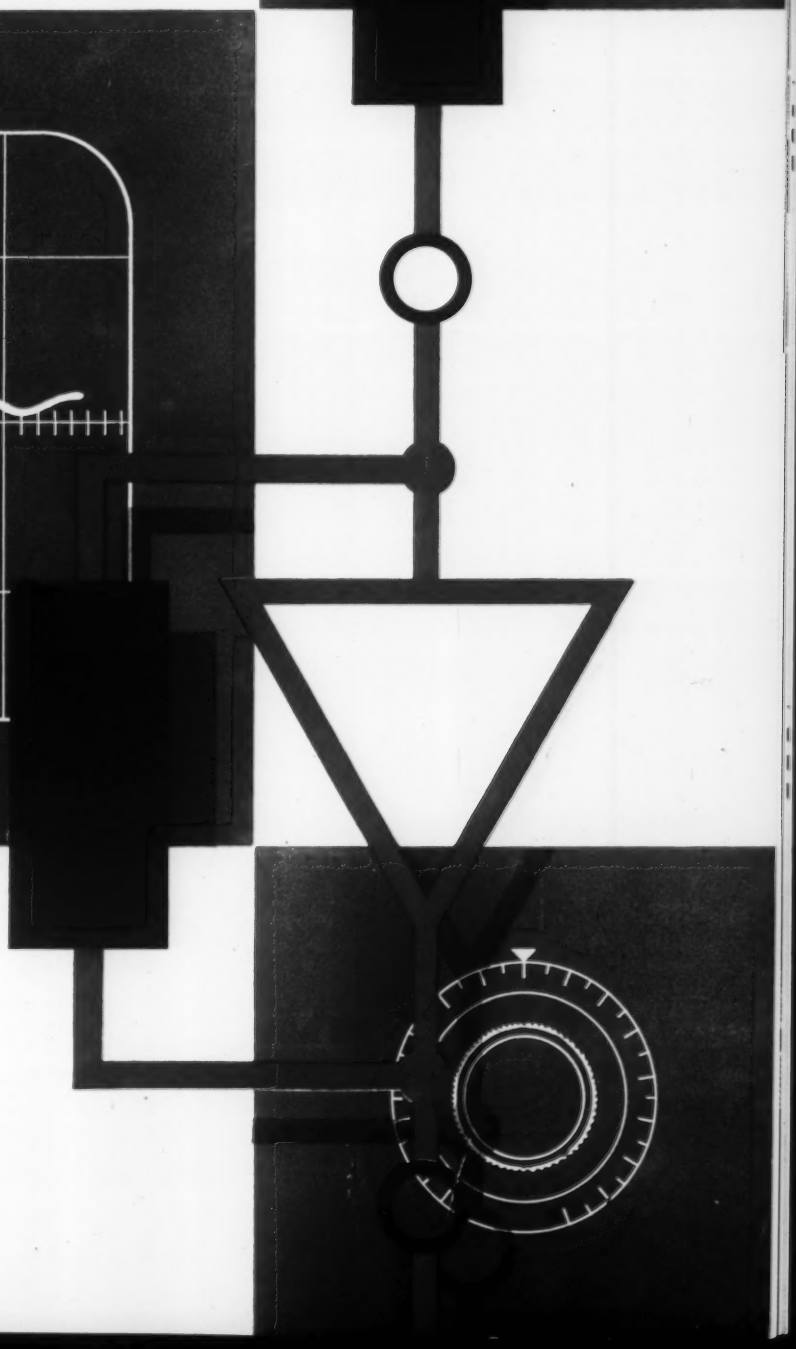

Analog Simulators

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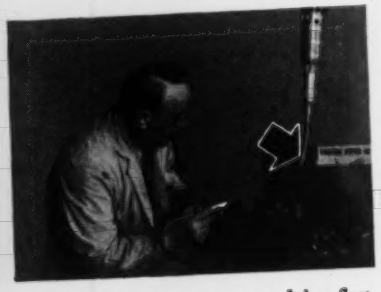
FLEXIBLE SHAFT IDEAS for ENGINEERS

How fast can a power drive flexible shaft be operated?



GENERALLY SPEAKING power drive flexible shafts are designed to operate at speeds of 1,750 to 15,000 rpm. However, there are many applications where higher speeds are attained especially in the case of small diameter shafts.

Pictured is a portable tool in which an S. S. White flexible shaft operates at speeds up to 45,000 rpm. According to the manufacturer, the success of the application is due to the "very high operating speed and excellent torque transmission possible through the flexible shaft . . . which runs cool and without vibration."

High speed remote control flexible shafts meet many requirements

WHEN TRANSMITTING CONTROL to parts through small reversible electric motors, the use of high speed remote control flexible shafts should definitely be considered.

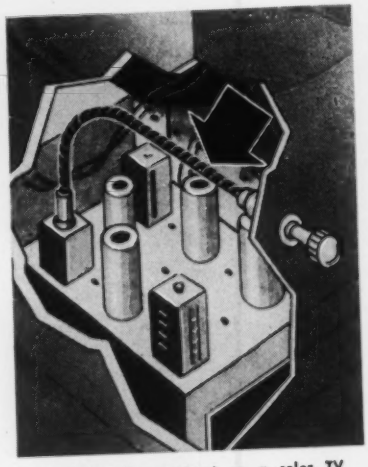
These shafts have been especially developed for intermittent operation in either direction of rotation at speeds up to 3,000 rpm.

But, their ability to operate around turns, the ease with which they can be installed, and their compactness offer definite advantages for many industrial applications.

We'll be glad to send details if you write stating your requirements.

Flexible Shafts offer big advantages when power or control goes around turns

Eliminating design and installation problems saves time and costs and improves performance

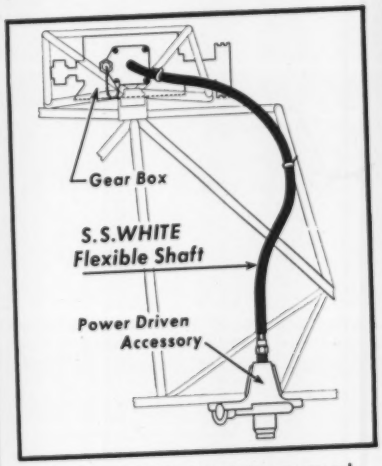


Regulating hue contrast on a color TV receiver is simplified by a flexible shaft coupling between control knob and circuit element. Note 90° turn.

ONE OF THE IMPORTANT ADVANTAGES of a flexible shaft is its ability to operate around turns and under conditions where alignment difficulties make a solid connection either impractical or uneconomical.

This fact is of prime importance when working out any design where power or control has to be transmitted between two parts. It assures greater design freedom. It simplifies manufacturing and assembly procedures. And it brings about important savings in costs as well as improvements in performance.

The two illustrations above graphically illustrate how S. S. White flexible shafts provided effective, cost-saving solutions to two power and control problems.



A power drive flexible shaft, run around intervening struts and frames, provides a dependable easy-to-install drive for a helicopter pump.

Think of your own equipment. Can you see where you could improve it through the use of flexible shafts? Our engineers will be happy to cooperate with you in making recommendations. There's no obligation, of course.

USEFUL FLEXIBLE SHAFT DATA

Bulletin 5601 has concise information on how to select and apply flexible shafts. Send for a copy.

FS-3

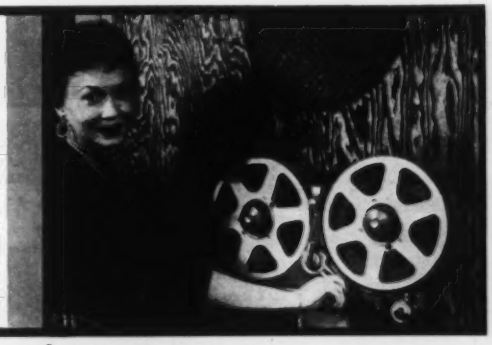
FIRST NAME IN FLEXIBLE SHAFTS

S. S. White

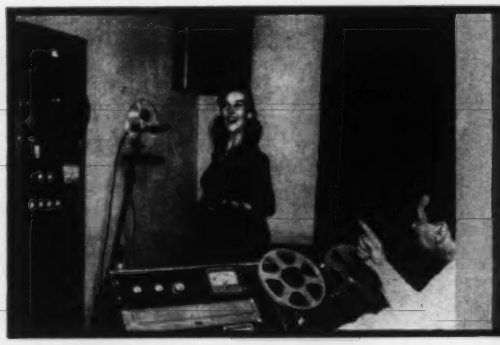
S. S. WHITE INDUSTRIAL DIVISION, DEPT. 4, 10 EAST 40th ST., NEW YORK 16, N.Y.

Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

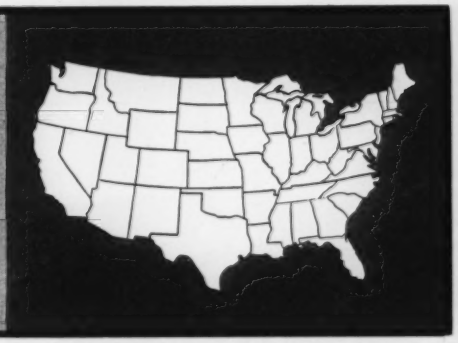
Why Bodine motors were selected for Berlant Tape Recorders



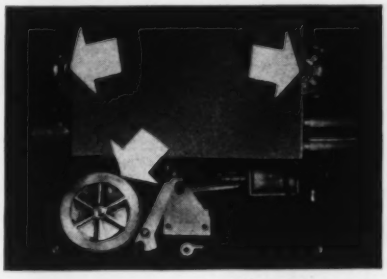
1 This is a professional, automatic tape recorder ...made by Berlant Instruments in Los Angeles.



2 It's used in radio stations, recording studios, motion picture studios...and for many applications in industry.



3 These recorders, the makers state, are made to specifications suggested by engineers responding to a national survey.



4 Three Bodine Motors are used to power these professional recorders...two Type KCI-42 and a Type NCH-33.

5 This gentleman is Mr. Bert Berlant, president of Berlant Instruments, Los Angeles, manufacturers of Berlant Recorders.

"Ever since we went into business we have been using Bodine motors for our recorders. Our motors must be relatively small in size, long lasting and quiet in operation. The Bodine engineers have come up with the ideal solution in a set of motors for a professional tape recorder where performance is the direct result of the stability of the drive mechanism."

BODINE

BODINE

fractional horsepower

MOTORS

6 And here, Mr. Berlant tells why Bodine Motors are used to power Berlant Recorders.

7 Be sure your motor is as good as your product. For information contact Bodine Electric Co., 2258 W. Ohio St., Chicago 12.

BODINE MANUFACTURES FRACTIONAL HORSEPOWER ELECTRIC MOTORS FOR:

adding machines
letter openers
sanders
vending machines
exhaust fans
duplicating machines
portable tools
sound recorders
air conditioners
check protectors
respirators
voltage regulators
x-ray timers
traffic signal timers
stirrers
calculating machines
envelope sealers
diesel governors

. . . and for many other applications.

Ask for a sample copy of 'The Motorgram,' a bi-monthly publication discussing the application and design of fractional horse power electric motors.

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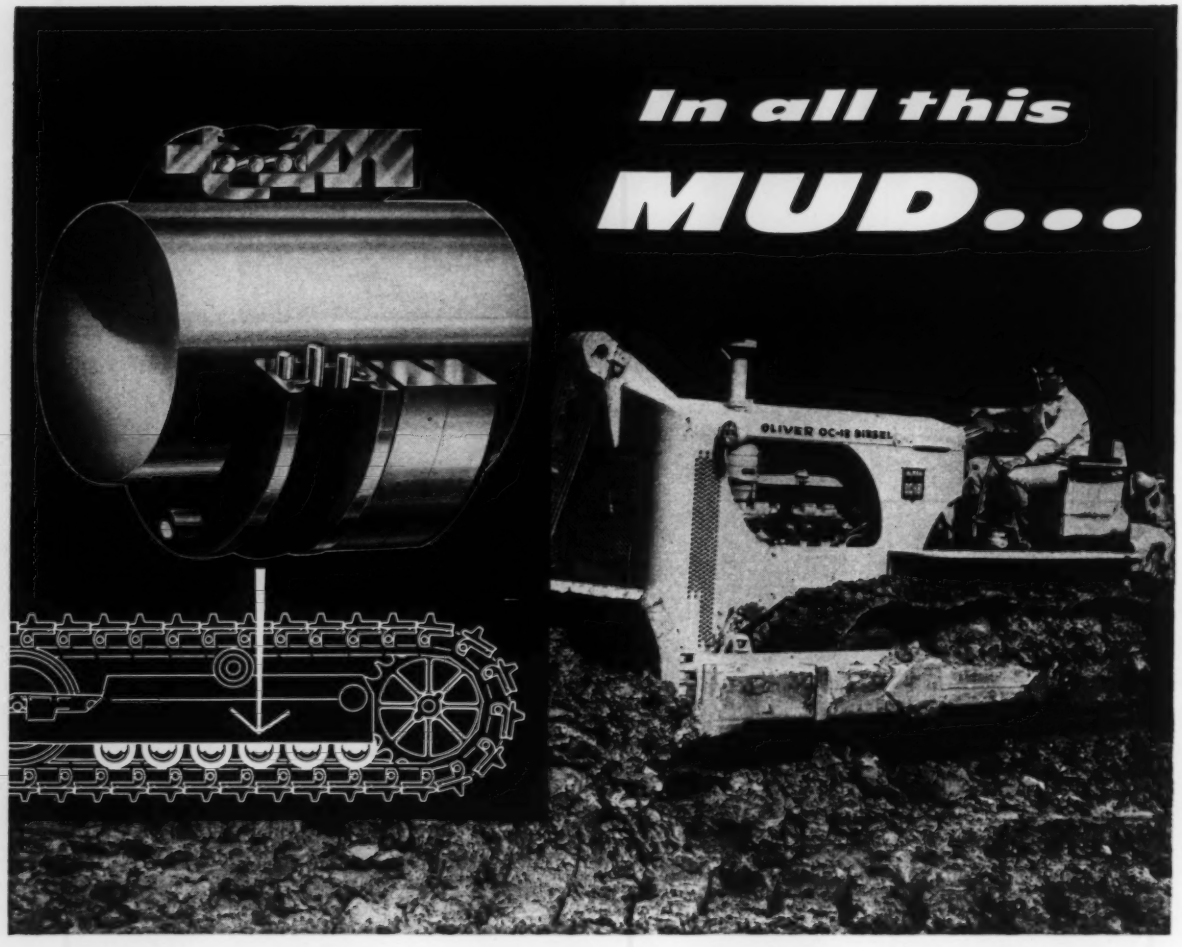

TRACK WHEEL BEARINGS ARE COMPLETELY PROTECTED

Whether it's tropical muck or crystal sharp Alcan dust, nothing sneaks past the C/R End Face Seals guarding the track wheels of this giant Oliver OC-18 Crawler. And here's why: The mating rings in this steel-on-steel C/R Seal are lapped flat within .000034 inch! They form a leakproof seal so dependable that even under the worst field conditions the oil and the bearings stay clean and the oil level does not require the usual frequent checking. Seal performance like this cuts downtime for lube checks . . . saves big money on round-the-clock operations. You can have equally dependable performance . . . and savings . . . with C/R Oil Seals.

C/R engineers will cooperate with you on special designs, or help select the right stock seal for a wide range of applications. Write for detailed information.

More automobiles, farm and industrial tractors rely on C/R Oil Seals than on any similar sealing device.

CHICAGO RAWHIDE MANUFACTURING COMPANY
1221 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities. See your telephone book.

In Canada: Manufactured and Distributed by Super Oil Seal Co., Ltd., Hamilton, Ontario

Export Sales: Geon International Corp., Great Neck, New York

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CHICAGO RAWHIDE

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Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

August 9, 1956
Volume 28—No. 16

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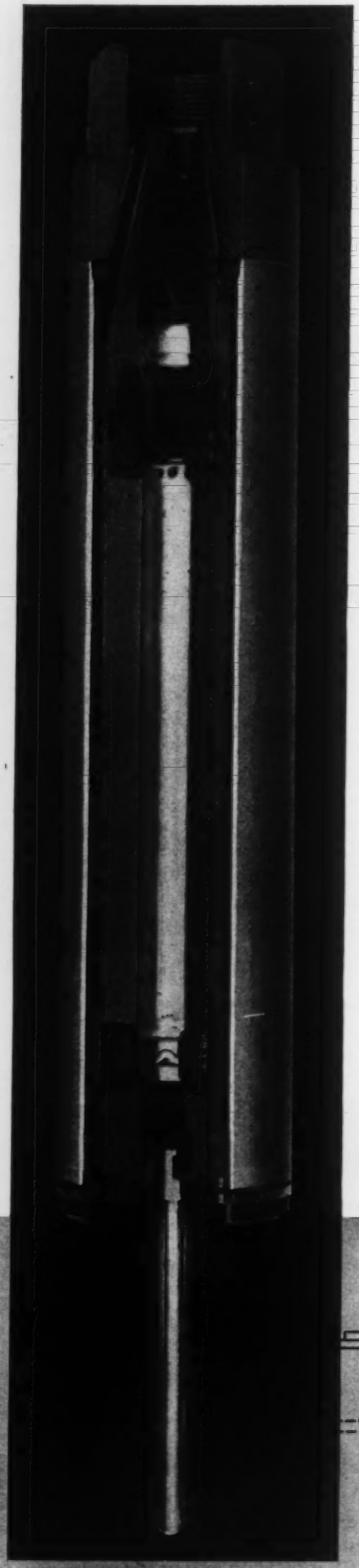


7 "bonus values" of Leland's submersible motor!

Now both motor and pump can be installed right in your gasoline storage tank! Even with high octane gasolines, the new Leland explosion-proof motor eliminates vapor-lock . . . uses the gasoline itself for lubrication and cooling. This completely new ¾ hp, 230v AC thermally protected motor measures only 3½ inches in diameter . . . fits into existing tanks. It's fully U.L. Approved for Class I, Group D service.

Simple and rugged, built for long-life economy, this new Leland submersible pump motor has these 7 big advantages over other motors:

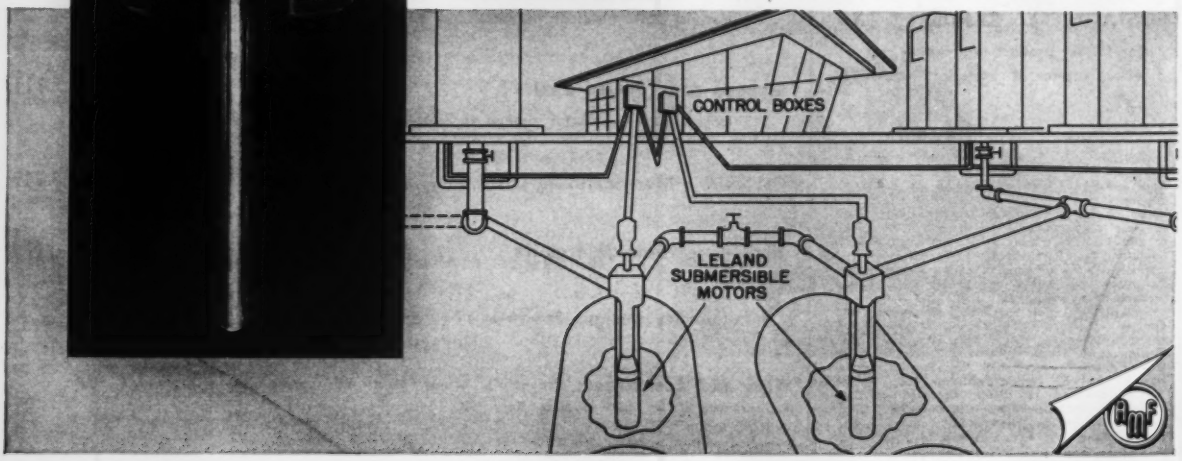
1. Completely self-contained unit includes outer shell necessary for gasoline passage – makes expensive extras unnecessary.
2. Extruded aluminum outer shell becomes main structural member – ribbed design provides much needed rigidity.
3. 9/16" chrome-steel shaft extension provides greater strength–prevents mechanical distortion.
4. Increased annular area allows 10% greater gasoline flow–minimizes trouble-making back pressure and turbulence.
5. Suction stub mounts without adaptor castings – reduces expense required with other motors.
6. Plastic-impregnated windings surpass wet-design insulation requirements – remain trouble-free for extra-long service life.
7. Leland's integrated motor design permits complete removal of pump or stub *without* disassembling motor.

In addition . . . a remote-control box is supplied with each Leland submersible pump motor. Includes thermal overload protector, line control and starting relays, starting and running capacitors.

30 years ago Leland developed the first gasoline curb pump motor to receive U.L. Approval – today, Leland gasoline pump motors outsell all others combined. So there's good reason why, for explosion-proof motors of any kind, your best bet is Leland. For more information, write, wire or phone us – TODAY!

Another AMF Product
LELAND MOTORS

THE LELAND ELECTRIC COMPANY
Dayton 1, Ohio
Division of AMERICAN MACHINE & FOUNDRY COMPANY



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Engineering News Roundup

New Conductor Stays Strong At High Temperatures

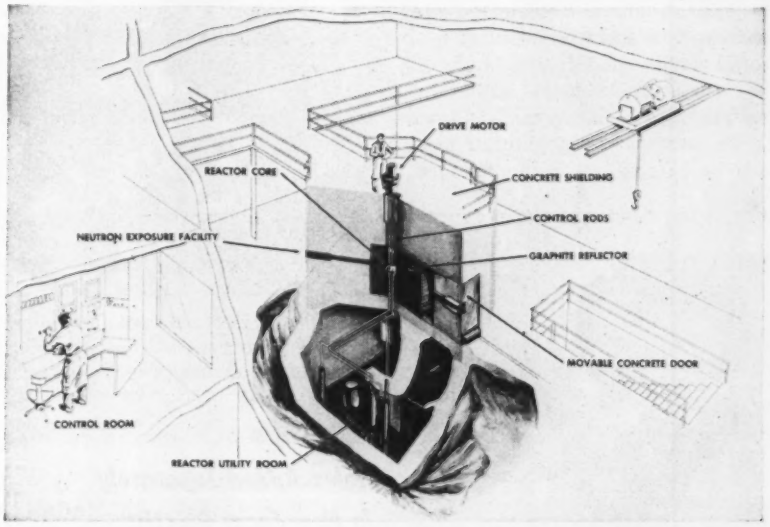
COLUMBUS, O.—A copper-zirconium alloy possessing high electrical conductivity and good strength-retention at elevated temperatures has been developed at Battelle Memorial Institute. It is suitable for electric motor commutators serving at temperatures above 500 F and under conditions where strength is required.

Electrical conductivity of the alloy is 95.8 per cent of that of the copper standard. Rate of loss of strength under load is exceptionally low by commutator alloy standards.

Other properties of the copper-zirconium alloy, which is now in commercial production, include good machinability, ability to develop and maintain a commutator film, and strength increase with notching. Reports of commutator performance tests, both at sea level and at high altitudes, indicate that brush life with the new alloy is at least equal to that with similar commutators made from silver-bearing copper and chromium-copper alloys.

Notched and unnotched specimens of the new alloy exhibited rupture strengths on the order of 32,000 to 41,000 psi in 100 and 500-hour creep-rupture experiments conducted at 550 F. Notches strengthened the copper-zirconium alloy, loaded in either transverse or longitudinal direction.

These properties make the new alloy suitable for commutators operated at temperatures above 500 F and at high stresses, such as in motors subject to severe vibration. The copper-zirconium alloy also possesses sufficient ductility to eliminate a substantial amount of commutator bar cracking—another cause of motor failure.



First nuclear reactor for private industrial use is now in operation at Armour Research Foundation, Illinois Institute of Technology. Atomic fission takes place in reactor core and is contained within shield of concrete 5 ft thick.

First Private Industrial Reactor Now Operating

CHICAGO, ILL. — Operation of the first nuclear reactor built for private industrial research was begun recently on the campus of the Illinois Institute of Technology. The 50,000-watt research reactor was designed and built by Atomics International, a division of North American Aviation Inc., for the Armour Research Foundation.

Core of the new reactor is this stainless steel sphere about 1 ft diam.

The reactor opens a new field in industrial research and development by providing a source of high-energy gamma rays and neutrons. Short-lived radioisotopes, useful in medical, industrial and scientific research, will be available from the reactor. It will not be used to generate electrical power.

As fuel, the reactor uses enriched uranium dissolved in about 4 gal of water. Atomic fission, the "splitting" of atoms which produces radioactivity and neutrons, takes place in the reactor core, a steel sphere about 1 ft in diameter.

A feature of the reactor is its "self-contained" design which confines all the radioactivity within

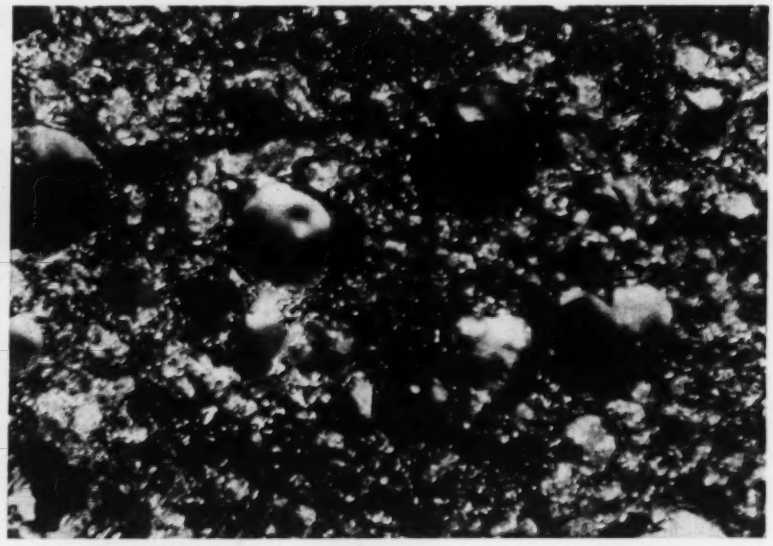
a shield. No gaseous or liquid materials are exhausted or discharged.

The reactor will be used in many fields, including biology, petroleum technology, metallurgy, electronics, textiles and chemistry. Of particular interest are studies in the atomic radiation of foods to extend the time they can be kept edible.

Because radioisotopes send out "signals" that can be detected and measured, a small quantity of material can be radioactively "tagged" and its invisible course traced in metals, plants and animals. Flaws in the casting and welding of metals can be detected in this manner.

TINY TV CAMERA has been developed by Lockheed Aircraft Corp. to help in flight testing the new Electra propjet airliner. This 8-mm. eye will be used in inaccessible or hazardous places on the plane. Its observations will be carried to monitors inside the craft. Camera and lens weigh 1½ lb and measure 1¾ by 2 by 5 in.

First Creative Engineering Program at the Army's Engineer Research and Development Laboratories, Fort Belvoir, Va., was concluded recently. Leading psychologists and Laboratories' personnel presented views on creative thinking to 150 professional and technical personnel.



Nitrogen-filled Microballoons, ranging in diameters from 0.0002 to 0.0036-in., are mixed with a variety of resins to enable close control of final "foamed" structure. The lightweight plastics can be used to reinforce boat hulls, insulate refrigerators, and stiffen airplane wings.

Holes Added Separately In New Foam Plastics

NEW YORK, N. Y.—Unusual lightweight plastic materials, called "syntactic foams," with a cell structure like wood but easily controlled densities and strengths, have been developed recently by the Bakelite Co. The new materials are designed for a variety of uses such as to reinforce boat hulls, insulate refrigerators and stiffen airplane wing structures.

Exceptionally uniform cellular structures, free of voids or dense areas are produced by bonding microscopic phenolic spheres together with polyester, phenolic, or epoxy resins.

The tiny hollow spheres which form the cells are Microballoons, originally developed in co-operation with Standard Oil Co. (Ohio) to reduce crude oil evaporation from cone-roof storage tanks. Average size of the Microballoons is 0.0013-in. diam, and the range of sizes is 0.0002 to 0.0036-in.

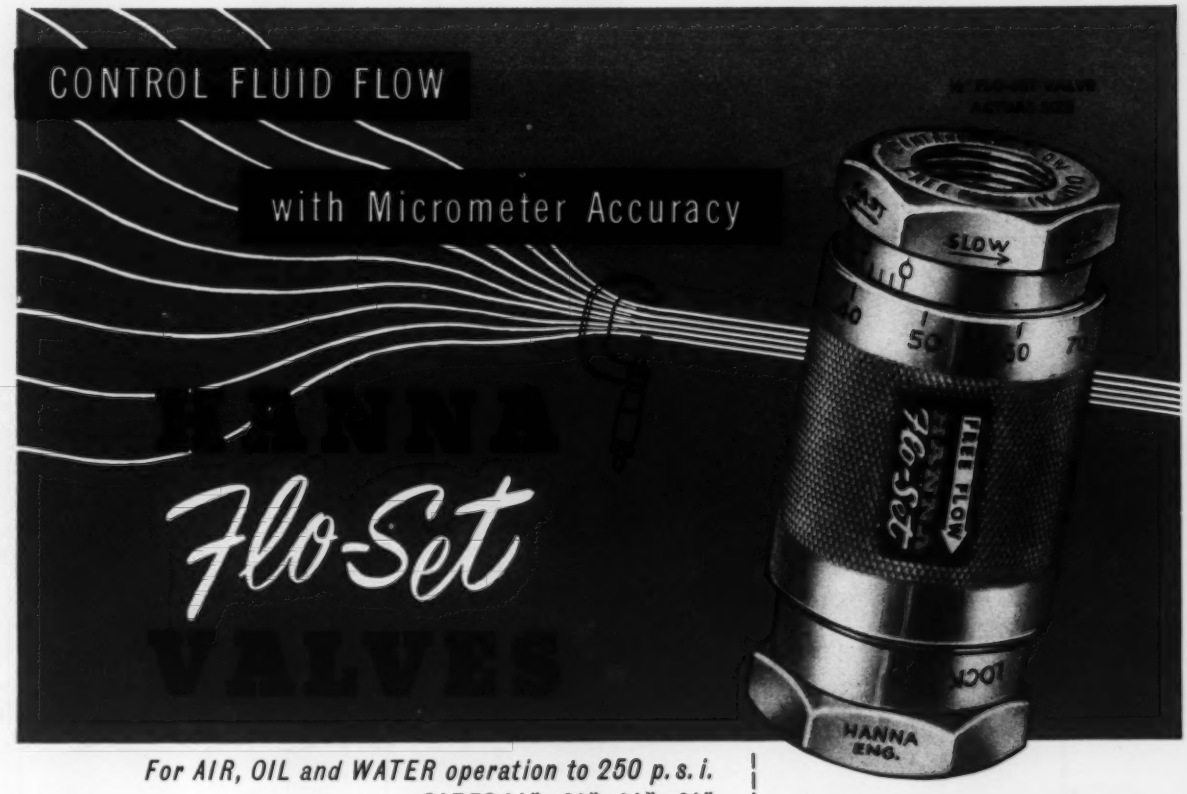
Low-cost sandwich structures with syntactic foam cores between glass fiber mats reinforced with polyester resins show flexural strengths ranging from 1700 to 4500 psi, tensile strengths between 1600 and 2900 psi, and compressive strengths as high as 12,100 psi. It is claimed that such rigid cores reduce the flexibility of reinforced plastics without increasing weight.

The tiny hollow spheres with sealed-in nitrogen gas provide the syntactic foams with inherent thermal insulating properties. Castings of the plastics make use of their insulation value without adding appreciable weight.

Victory over vibration in a pneumatic hammer has been scored by Illinois Institute of Technology researchers. In an Armour Research Foundation-sponsored project, a pneumatic spring was placed between the handle and the main part of a prototype hammer so

Front Cover

According to Webster's dictionary, to simulate means "to assume the appearance of, without the reality." With analog simulators—highlighted on artist George Farnsworth's front cover—many physical quantities, such as vibration, can be counterfeited by an electrical quantity, such as voltage. J. N. Macduff's article (see Contents page) covers the subject in detail.


CONTROL FLUID FLOW
with Micrometer Accuracy
HANNA
Flo-Set
VALVES

For AIR, OIL and WATER operation to 250 p.s.i.
SIZES ¼" • ⅜" • ½" • ¾"
TEMPERATURES to 250°F

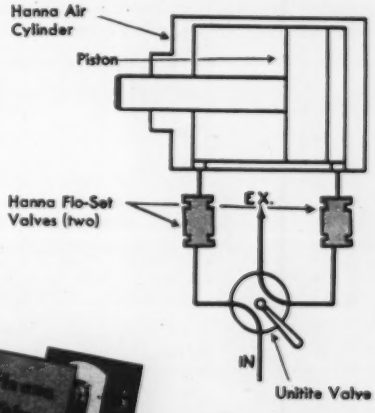
Hanna Flo-Set Valves are used to control cylinder piston speeds and operating speeds of many types of fluid actuated mechanisms. They are able to handle air, oil, water and many gases. When used with cylinders, these valves permit independent adjustments of forward and return piston speeds. The diagram at the right shows a typical circuit. Flo-Set Valves make the operation of air cylinders smoother and make cushioned cylinders more effective by building up essential back pressure.

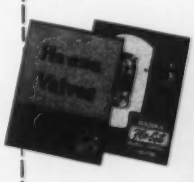
Fluids pass unobstructed in the direction of the arrow on Hanna Flo-Set Valves. In the opposite direction, flow can be controlled from zero to full pipe capacity. One valve can be set to an infinite number of controlled flow positions. Once set, the position can be held by means of a locking collar. Established flow positions can be reset by using the micrometer graduations which accurately measure flow as a percent of full pipe capacity.

One revolution of the aluminum valve body will change the flow rate from zero to full capacity. No tools are necessary! In addition to the standard ¼", ⅜", ½" and ¾" sizes, there is a ¼" Jr. model, without micrometer graduations or locking collar, for light piping and tubing.

Typical Cylinder Circuit Using Hanna Flo-Set Speed Control Valves

Hanna engineers will gladly recommend circuits to help you with your applications.





Consult your classified telephone directory or Thomas' Register for your nearest Hanna representative. Write for Hanna Valve Catalog 254 and Flo-Set Valve Bulletin 253A.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1751 Elston Avenue • Chicago 22, Illinois

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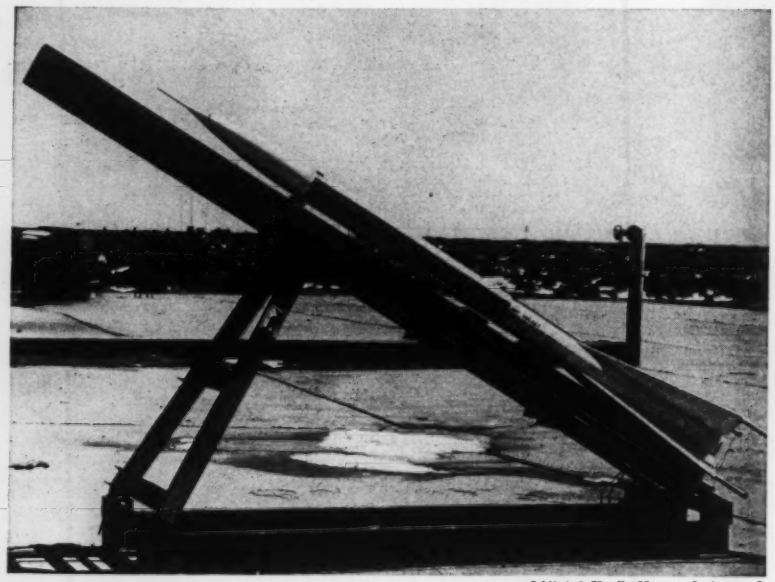
that vibrations are absorbed by the hammer itself instead of its operator. Elimination of vibration is accomplished without excessive pressure loss or reduction in work. There is a possibility that the hammer may be made to deliver the same work output as standard pneumatic tools, with no increase in weight.



Official U. S. Navy photograph

ATMOSPHERE SOUNDING PROJECTILE, ASP for short, has been developed for the Navy Bureau of Ships by Horning-Cooper Inc. Poised here on its simplified launcher, ASP can be fired vertically for altitude soundings or at an angle for long-range soundings. Transmitters in the rocket broadcast weather information, cosmic ray emanations and other geophysical data. The ASP was built in less than five months.

Official U. S. Navy photograph

SECOND FIGHTER IN A NEW CLASS is the U.S.S. *Canberra,* recently put to sea for builder's trials. Converted from a conventional cruiser, the 673-ft ship now carries launchers for Terrier guided missiles. The missiles are stowed below decks and fed to launchers by automatic loaders. Radar and other electronic equipment detects targets and guides the missiles. The *Canberra* is the only Navy ship named for a city in a foreign country.

Topics

Self-cleaning cars are seen as a future possibility by a Ford executive. The painting technique would involve factory-coating the automobile with photosensitive pigments of a neutral shade. Desired color would be applied by the dealer with an electromagnetic radiation gun. Such a finish would have the ability to expel dirt from its surface when passed through an energy field.

• • •

Portable air conditioning is available in the form of a 14-lb unit made by American Dryer Corp. It is said to operate at maximum efficiency for four hours, providing cool air around a person at a desk or in an automobile.

• • •

Big boat with a small price tag is the goal of Coleman Boat & Plastics Co. through the use of fibrous glass hulls. By fall this company expects to be producing 40-ft plastic sailing sloops at about half the price of wooden ones.

• • •

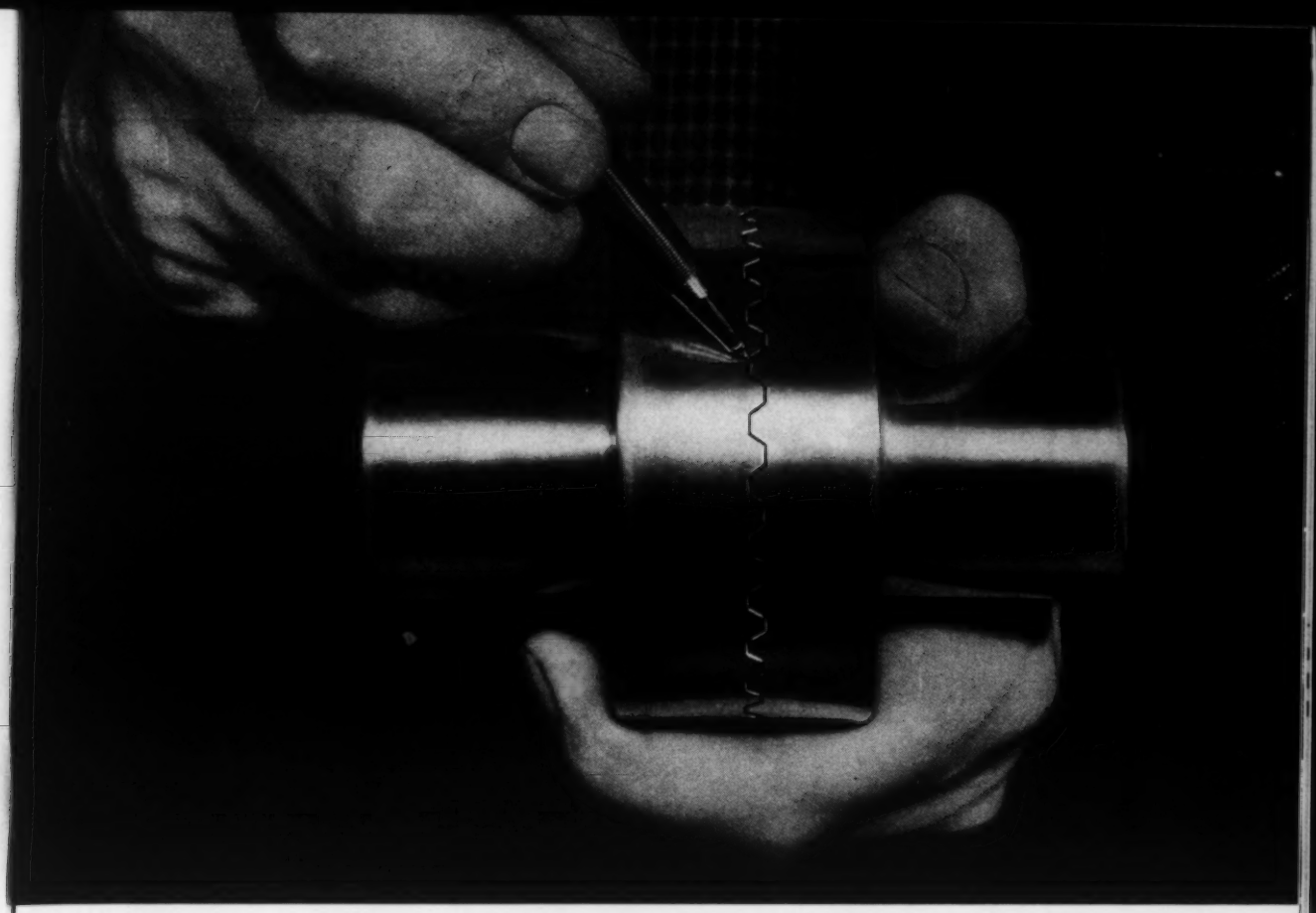
Inertial guidance system for a missile is being developed for the Air Force by the AC Spark Plug Div. of General Motors. The basic concept of such a missile is that it must be guided to its target without use of radar, radio, or any reference from the ground or sky. The guidance system is merely set for the correct latitude and longitude of launching and target points. Guidance is achieved by means of extremely accurate gyroscopes.

• • •

Two old-fashioned submarines—powered by diesel engines—have been ordered by the Navy. Subsequent subs will all be nuclear-powered, according to present plans.

• • •

Rockets will be fired at the U. S. from West Germany within five years, according to the Bremen Working Group for Rocket Technic. This group, which includes men who worked on the V-1 and V-2 projects, is developing a mail-carrying rocket and expects to send postal cargo over the Atlantic at a speed of 3000 mph and at a cost that will be "infinitesimal" contrasted to carrying mail by transatlantic jet aircraft.



This photograph shows tooth contact of a Curvic Coupling used in an aircraft drive shaft. The coupling simplifies the manufacture and assembly of this shaft and permits "in the field" maintenance.

CURVIC® COUPLINGS—*what they are and how they can help improve your product*

Curvic Couplings are precise face splines that drive, center and align parts with a high degree of accuracy.

They can improve your product by giving improved design, simplify maintenance through the use of interchangeable parts and lower production costs by eliminating the need for large complex parts.

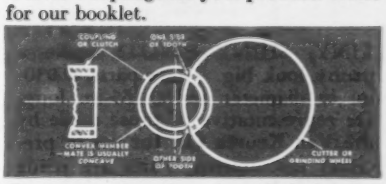
Because Curvic Coupling teeth curve lengthwise—either concave or convex—contact between the joining teeth is controlled. The load carried is equally distributed on all teeth as tooth-to-tooth spacing is held to extremely close limits. Therefore, Curvic Couplings can be made smaller, thinner and lighter than many other types of toothed connections.

Three principal types

1. *The permanent Curvic Coupling* is used for driving *and* aligning. It is for such uses as building up accurately balanced, precision rotors for jet aircraft engines. Curvic Couplings can hold mating parts within 0.0005" total runout.
2. *The semi-universal Curvic Coupling* allows misalignment of shafts (2° maximum) together with axial freedom. Localized tooth bearing prevents load concentration on ends of teeth.
3. *Shift and overload Curvic Clutches* maintain proper tooth contact while the clutch engages and disengages. Shift clutches are used in washing machine wringer drives, motor trucks, outboard motors, aircraft —wherever a positive toothed clutch is needed.

Overload clutches are used where the amount of torque to be transmitted must be regulated, as in power screwdrivers.

The Gleason Engineering Department will be glad to consult with you regarding Curvic Couplings for your product. Write for our booklet.



The drawing above shows the method of producing both sides of Curvic Coupling teeth with the same surface of the cutter or grinding wheel, so that both sides have the same curvature. Curving the teeth lengthwise in this manner assures control of contact between joining teeth.

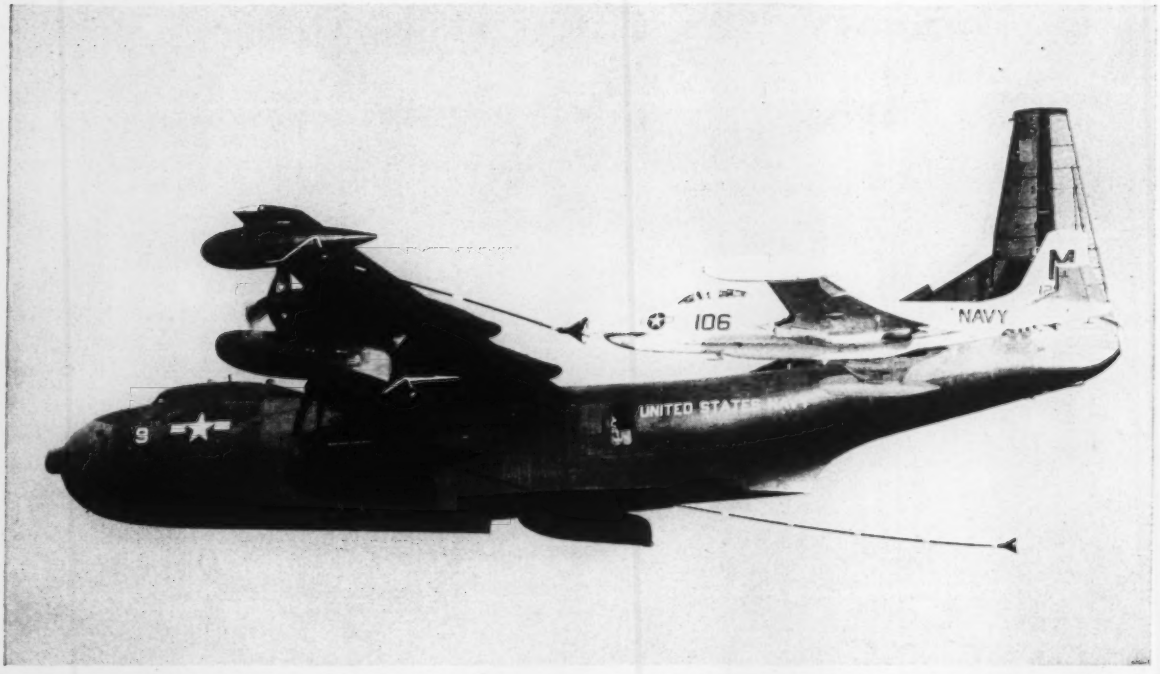
GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

—ITEM 508—

For More Information Circle Item Number on Yellow Card—page 19



TRADEWIND TANKER TRANSPORT demonstrates one of its two main jobs by fueling smaller Navy fighter in flight. The first seaplanes to be fitted as tankers, the Convair Tradewind transports will be equipped to fuel four fighters simultaneously by the probe-and-drogue method. The big planes can carry fuel for 8 smaller craft, 24 tons of cargo or 80 passengers. One version, called the "Flying LST", has loading doors in the bow.

TINY, SHINY PIVOTS make a penny look big. These parts, 0.030-in. in diameter and 0.165-in. long, are representative of those made by the Van Keuren Co. for use in precision instruments. Parts are made of Carboloy's tungsten carbide to provide required wear resistance and surface finish. Concentricity of parts must be uniform with roundness held to within 10 to 20 millionths of an inch.

New Developments Seen In Auto Manufacturing

DEARBORN, MICH. — Engineering educators attending the Ford Engineering Forum recently were given a glimpse of forthcoming developments in automobile manufacturing by Del S. Harder, Ford executive vice-president for basic manufacturing divisions. Mr. Harder also emphasized the importance of all the branches of engineering in Ford manufacturing operations and observed that manufacturing continually presents new horizons for technical accomplishment.

Initially, Mr. Harder noted several prospects for improvements in the making of steel — the basic material for automobiles. "It is entirely possible that current experimental techniques will be perfected so that we will take the molten steel right from the refining furnace and cast it continuously through a water-cooled copper mold into semi-finished slabs.

"A recent forward step . . . has been the addition of boron to steel for its protection while in storage. It has been discovered that boron, which is plentiful and quite inexpensive, will greatly improve the quality of deep-drawing sheet metal."

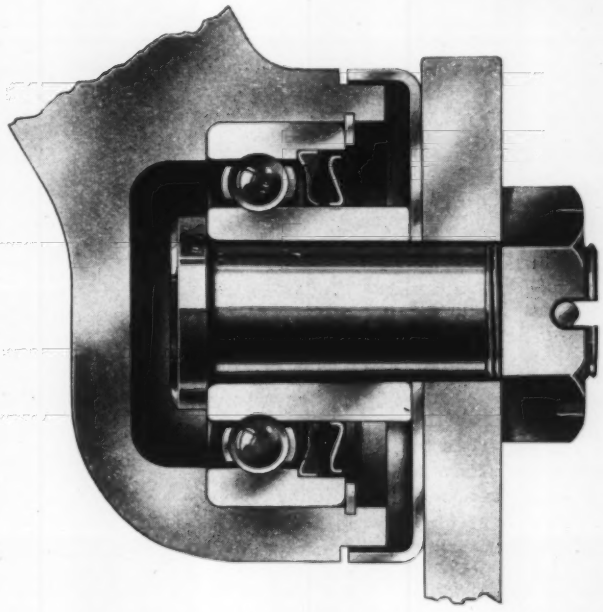
Another prospect in the field of materials is photo-sensitive pigment paint. "Our research people can picture all cars shipped to the dealer from the factory being a neutral white. Any color, or combination of colors, that his customer wanted would then be brought about by playing a controlled electro-magnetic radiation gun over the neutral white paint.

"The future in materials might include the alloying of aluminum, titanium, and magnesium, with unique materials like columbium. The idea would be to alloy them in such a way as to vastly improve their engineering properties.

"Extensive research and study has gone into the possible use of

FACTS

about **NEW DEPARTURE**
BALL BEARINGS



Bearings are fully protected by flexible seal and metal slingers. Ample grease supply, kept free of contaminants, eliminates all need for relubricating. This means maintenance is zero.

HAY RAKE BEARINGS... DESIGNED FOR NEGLECT

These NEW Departures in hay rake tine bar bearings have been developed to give both implement manufacturer and user bearings that are easily applied. Once installed, they can be entirely neglected—they are "built to be forgotten"!

New Departure hay rake bearings are designed to mount on standard machine bolts . . . or on flat-head, slotted studs like those shown in the sectional view. These special studs are available from New Departure.

When you specify New Departure ball bearings for farm implements, you are assured of bearings of proved capacity and performance. Complete details sent upon request.

Bearing bores are accurately sized to fit correctly on either standard machine bolts or on special studs shown. Bearings retained in tine bar end by simple snap ring. No drilling, tapping or threading required.

BALL BEARINGS MAKE GOOD MACHINES BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

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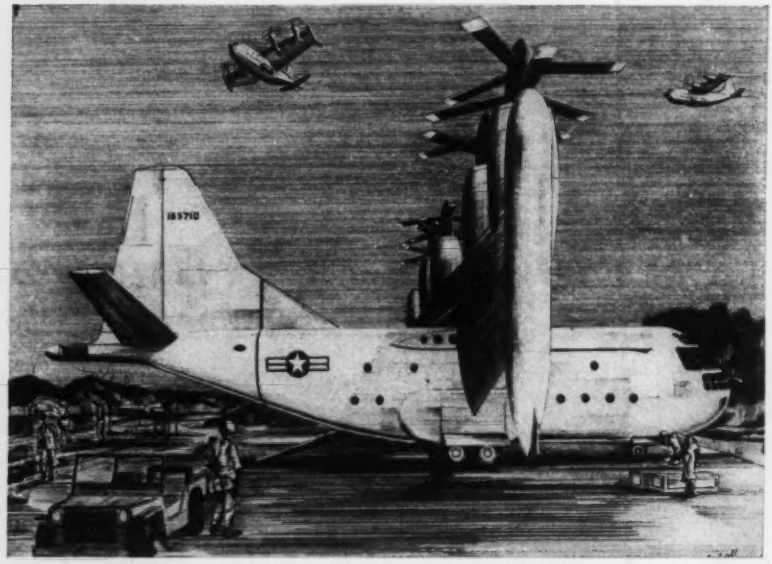


FLYING CARGO IN TIGHT QUARTERS would be the job of this tiltable wing transport proposed to the Army by Hiller Helicopters. Except for hovering, landing and take-off, plane's wing and motors would be turned horizontally as on conventional craft.

aluminum in our production. We have developed aluminum-finned radiators and they are presently being tested in the field. In the very near future we hope to have all-aluminum radiators.

"A large number of parts, such as aluminum cylinder blocks, might be produced from the basic materials with final machining almost eliminated. A hot metal pressure-molding process, which might best be described as high-pressure die casting, may allow us to cast even complicated parts to finished shapes and sizes.

"New and improved plating processes will allow elaborate alloys to be deposited on the cheapest of base metals and still have the working surfaces that will meet engineering specifications."

Mr. Harder mentioned the possibility of cold extrusion supplanting machining in some cases. "The material cost is reduced in this process because a smaller amount of material is used to form the part than would be required if the part were shaped by conventional methods.

"Another recent development has been in the field of bonding techniques. When it becomes necessary to join dissimilar materials, there is a method which causes the very molecules of the materials to act upon each other and form a bond. This joining action is superstrong."

Mr. Harder said that materials handling was another promising field for future developments.

Further progress in automation is necessary to obtain production of greater quality and quantity. Current projects involve the use of magnetic tapes to control machine tools. Mr. Harder stressed, however, that such electronic devices will increase the need for technicians and more highly trained employes, and that fears of automation displacing masses of workers are unrealistic.

"There recently was a government-sponsored exchange of engineers between the United States and Russia. One of our company engineers . . . visited the Soviet Union and earlier a team of Russian engineers toured plants in this country. When the Russian engineers came here, . . . they insisted that their trip be scheduled to include the most advanced examples of automation. Russia certainly is bent on overtaking us in every possible way, and automation may make the difference."

Miniature Tape Recorder Is Battery-Operated

BROOKLYN, N. Y. — The convenience of a "secretary in your pocket" is claimed for the Midgetape recorder, introduced as the world's first battery-operated, pocket-size tape recorder by its manufacturer, Mohawk Business Machines Corp. It can record and play back anywhere.

Size of the recorder is 1⅞ x 3⅞ by 8½ in. Housed in an aluminum case, it weighs 2¾ lb. Also

contributing to the small size and light weight is the use of subminiature tubes and a printed circuit. Batteries are of the hearing aid type.

Dual-track tapes are contained in aluminum cartridges and accommodate 60 minutes of recording each. Tape is erased automatically as a new recording is made. It can be used about 300,000 times.

Radar-Viewed Air Battles Now Tape-Recorded

DOWNEY, CALIF. — An airborne tape-recorder which plays back the operation of an airplane's fire control (weapon direction) system during attack is being installed in four different Air Defense Command interceptors, according to a U. S. Air Force announcement.

Called NADAR, the recorder is a product of the North American Aviation's Autonetics Div., and will be used for pilot and aircrew

If your products call for aluminum tube, it will pay you to put your requirements up to Revere. For at this one source you can obtain virtually any aluminum tube you want . . . seamless drawn, welded, lockseam and others; in an extensive range of sizes, alloys and tempers; both round and other-than-round.

Revere has the men, machines and experience to produce tube that is right for its purpose as well as right on schedule. It will pay you to tie the progress of your business to the most dependable sources of supply. Call the nearest Revere Sales Office now. In all principal cities. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

Revere Aluminum Mill Products include extruded shapes, rod and bar; coiled and flat sheet, embossed sheet, circles and blanks; seamless drawn and welded tube; rolled shapes; electrical conductors; forgings; and foil. Revere is headquarters for tube, and can supply it not only in aluminum but in copper, copper-base alloys and electric welded steel.

—ITEM 510—

FILL OUT COUPON
FOR FACTS, SAMPLES

ALUMINUM COMPANY
OF AMERICA
2244-H Alcoa Bldg., Pittsburgh 19, Pa.
Gentlemen:
Please send complete specification data and samples of your aluminum fasteners.
Name
Title
Company
Address

Also here!

An Alcoa Aluminum Fastener should be used here!

It's an aluminum awning assembly, worth the lasting strength of Alcoa® Aluminum Fasteners. You avoid galvanic and atmospheric corrosion. You get perfect color match; you get the very highest quality product. Your local Alcoa distributor has a complete stock.

P.S. In this awning assembly, we suggest an aluminum sheet metal screw. One from Alcoa's complete line of aluminum fasteners.

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

YOUR GUIDE TO THE BEST IN ALUMINUM VALUE

ALCOA ALUMINUM FASTENERS

—ITEM 511—

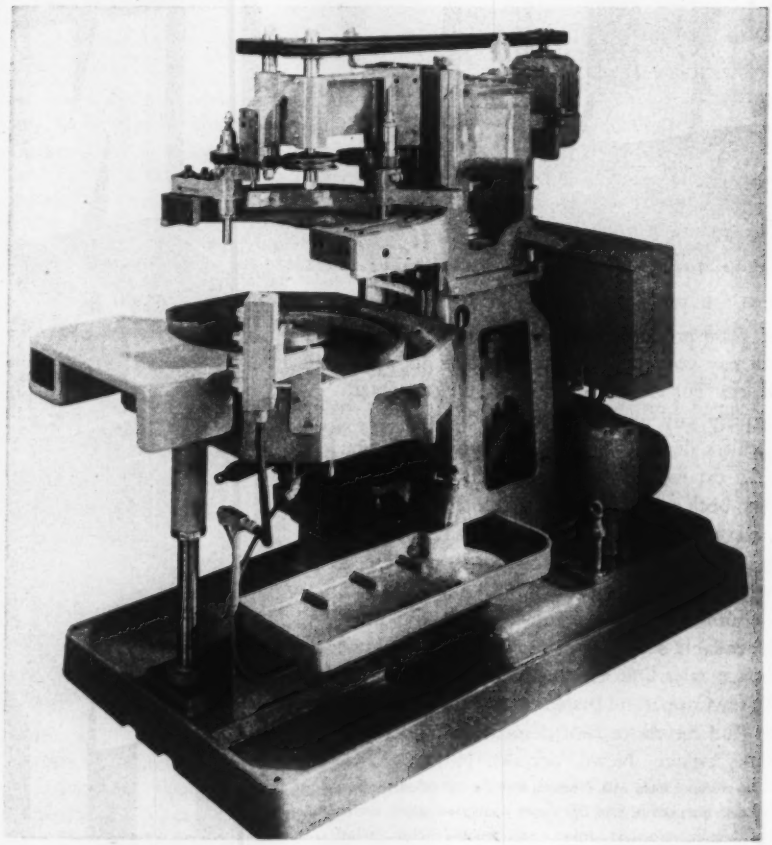
evaluation and training in Lockheed's F-94C, Northrop's F-89H, Convair's F-102A, and North American's F-86D.

The recorder converts information taken from the plane's radar equipment into signals representing position of the plane and target data. Operated electro-mechanically, NADAR goes into action when radar "lock-on" with the target is established.

After completion of a mission, the recorder's tape is installed in a reproducer for immediate playback. Then pilots and aircrews can review the attack operation.

At present, a number of the lightweight recorders have been installed in the F-86D Sabre Jet all-weather interceptors, and the Air Force has ordered more of the same type recorders and a proportionate number of reproducing machines.

DIALING A NEW FUSE is possible with the Sightmaster six-position household fuse. A tiny light indicates location of the fuse that has blown, and turning the knob slightly brings another into proper position in the circuit.



DO IT YOURSELF industrial tool is this new basic machine introduced by The Bodine Corp. Assorted standard spindles, feed units, index tables and dials, supplied by Bodine, can be added to the basic tool to make a variety of special machines. Different combinations of the basic machine and accessories can do a variety of machining and assembly operations.

Tests Measure Shock Loading of Textile Yarns

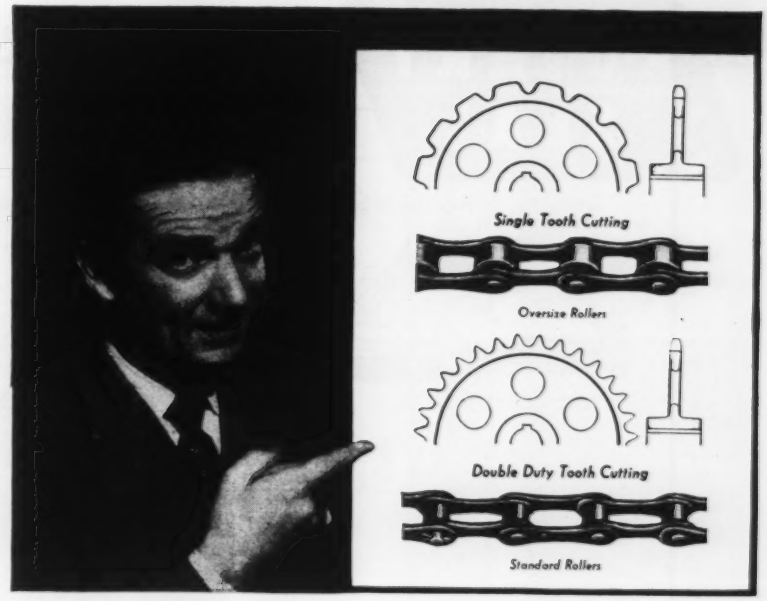
WASHINGTON, D. C.—The National Bureau of Standards has been making an extensive study of the behavior of textile yarns under very high-speed impact. The study seeks to determine the effects of high rates of strain on textile materials and to relate these results to the molecular structure of the fibers and the geometry of the yarns and fabrics. In this way, it is hoped, information leading to the development of fibers having improved impact properties will be obtained.

The ability of textile yarns to withstand high-speed impact stresses, or shock loading, is becoming increasingly important to modern industry and the national defense. Extremely high rates of strain are experienced by airplane tire cords during landing, by seat belts and safety lines when accidents occur, and by the fabric, shroud lines and webbing during the opening of a parachute. In high-speed industrial sewing, the thread is subjected to impact velocities ranging from 1 to 10 meters per second as often as 500 times per minute.

Important criteria in judging the ability of textile yarns to withstand shock loading include the magnitude and propagation velocity of the stresses and strains developed in the material, the energy absorbed and recoverable, and the energy to rupture. Two testing machines have been developed for studying these characteristics at rates of deformation from about 1000 to 10,000 per cent per second. One of these employs a pair of rapidly moving hammers to subject yarn specimens to longitudinal impact at speeds up to 80 meters per second. The other incorporates a spring-driven impeller and is used to study the effect of transverse impact with a projectile flying at speeds up to 65 meters per second.

Data from tests made on specimens of various lengths are used to compute the rupture energy

(*Continued on Page 22*)



Which Sprocket will live longer?

Here is double pitch chain applied on both a single and double duty tooth form sprocket. The single duty sprocket is necessary for use with double pitch chains using oversize rollers. The double duty sprocket used with double pitch chain having standard diameter rollers, has another 'life' by simply moving the chain up one tooth after it is worn in its first position. Double duty cutting in many cases, doubles the life expectancy of a sprocket.

FREE ACME CHAIN TEXT! Find information like this and plenty of other chain facts in the Acme Chain catalog. Packed with information and data on chain and sprocket application. Free to engineers upon request. 76 pages of tables and diagrams for ready reference. Write ACME CHAIN CORP., Dept. 6-F Holyoke, Mass.

ACME chains and sprockets are of unexcelled quality . . . available from distributors all over the U.S.A. and Canada. Contact yours, or write directly to us.

•

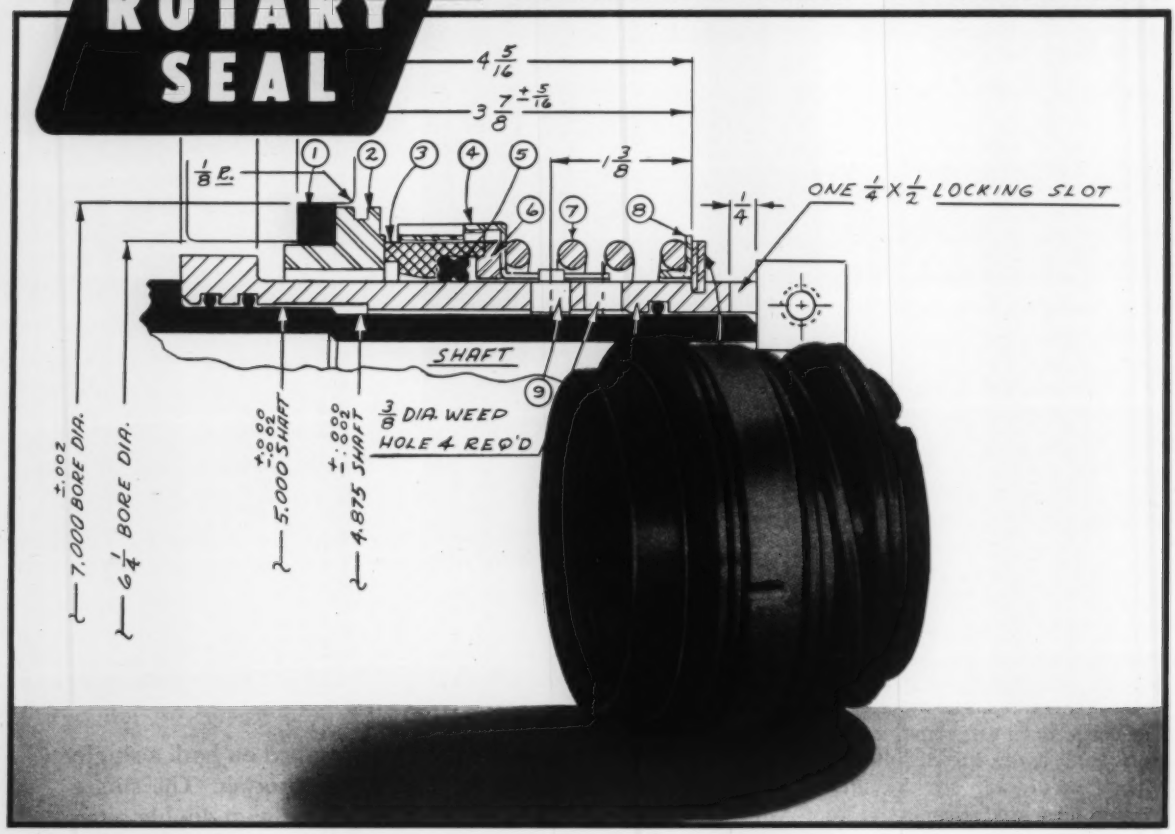
Call Holyoke JE 2-9458.

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

—ITEM 512—

ROTARY SEAL

SPECIALIZED SEAL ENGINEERING



is developing new ways to assure top performance in

HIGH-SPEED ELECTROLYTIC TINNING LINES

This brawny version of the famous ROTARY SEAL principles was carefully designed to meet some very rigorous operating conditions. An electrolytic tinning line moves at top speed, and keeps on moving, hour after hour, day after day. An unscheduled break in that continuous run is highly expensive—a few minutes gone, and a few hundred or thousand dollars may go too, in lost production.

This particular ROTARY SEAL, in addition to rugged construction, includes the same carefully engineered components as smaller varieties, with tolerances held to closest limits. Exactly the right materials were investigated, checked, then adopted to handle every challenge of the job—the long, hard runs, the corrosive action of solutions used in the tinning process. And special *unit construction* was worked out, so that the precision parts of the Seal would not be exposed to damage during installation, even at unskilled hands.

Solving hard Shaft Sealing problems is our business. Using the basic ROTARY SEAL principles which opened the way to successful mechanical Shaft Sealing when this company introduced them years ago, we "tailor-make" adaptations to fit each job precisely, knowing from experience that "off-the-shelf" compromises too often put trouble at the heart of the equipment.

Major assignments for important Seal developments are keeping us mighty busy at present; but if special difficulties are besetting your development progress, and production quantities of Seals are involved, we'll be glad to help if we can.

THE ROTARY SEAL Division of MUSKEGON PISTON RING CO.

mechanical seals for rotating shafts

Shaft-Sealing with Certainty

2022 NORTH LARRABEE STREET
CHICAGO 14, ILLINOIS, U. S. A.

—ITEM 513—
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Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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MACHINE DESIGN
AUG. 9, 1956

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418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
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425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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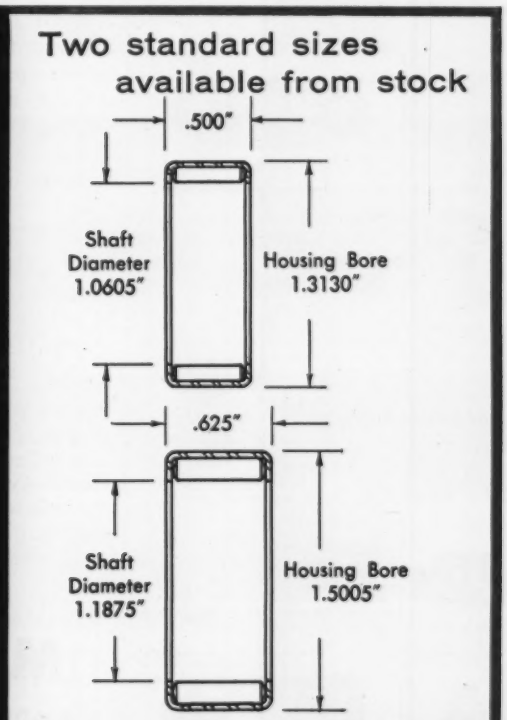
NEW KAYDON THIN-SHELL NEEDLE BEARINGS

Illustration is 2-times actual size of needle bearing



You get these Kaydon design advantages:

1. **Greater effective length needle rollers for MORE CAPACITY (41% on ½" width)... LONGER LIFE (2.8 times as much on ½" width)**
2. **Simplified construction that SAVES you money**
3. **Pre-packed lubrication that SAVES assembly time**

HERE it is! Kaydon's new thin-shell needle bearing. A bearing that gives you more of everything — more capacity... more economy... *plus longer life* than any other comparable bearing, because of greater effective length of spherical end rollers.

This new bearing is ready for you right now from stock in two standard sizes (illustrated). Other sizes will be available later.

For complete specifications, ask for Data Sheet No. K562—write, call or wire Kaydon of Muskegon.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 124" outside diameter... Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

are you
LOOKING
for fine pitch precision gears?

If your requirements include 1/8" to 5" O.D.—180-16 D.P. AGMA Precision #3 Then, write us for prompt response, today!

H. O. Boehme, Inc.

Designers and Manufacturers Communication Equipment Precision Electro-Mechanical Apparatus Since 1917

915 Broadway
New York 10, N.Y.

—ITEM 515—

Engineering News Roundup

(*Continued from Page* 15)

density for the specimen material. Rupture energy density is a quantity that is characteristic of the material tested and is useful in engineering design. It gives the amount of energy required to break a unit mass of textile yarn.

If the rupture energy density is assumed to remain unchanged at impact speeds near 200 meters per sec, an associated quantity, the limiting breaking velocity, can be calculated. This quantity gives an estimate of the lowest velocity required to cause a break at the head of a specimen immediately upon impact. The limiting breaking velocity of high-tenacity nylon is 240 meters per sec.

The actual velocity that will just produce an immediate impact break is called the critical velocity. It is usually slightly less than the calculated limiting breaking velocity and depends on the shape of the stress-strain curve for the material. The limiting breaking velocity depends only on the area under the stress-strain curve.

LIFE SAVER for ditched pilots, this device automatically inflates a Mae West life jacket upon contact with water. Water entering the inflator dissolves an effervescent pill, which produces a cloud of gas. Pressure of the gas moves a piston and a plunger to fire a carbon dioxide cartridge that inflates the jacket. North American Aviation Inc., developer of the inflator, reports that the device performs its function within 15 seconds after immersion in water.

Meetings

AND EXPOSITIONS

Sept. 7-9—

Metal Powder Association. Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information can be obtained from association headquarters, 420 Lexington Ave., New York 17, N. Y.

Sept. 10-12—

American Society of Mechanical Engineers. Fall Meeting to be held at the Cosmopolitan Hotel, Denver. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 10-13—

Society of Automotive Engineers Inc. National Tractor Meeting and Production Forum to be held at Hotel Schroeder, Milwaukee. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 11-14—

Packaging Machinery and Materials Exposition, to be held at Cleveland Public Auditorium. Sponsors are Packaging Machinery Manufacturers' Institute and the 18th Annual Forum of the Packaging Institute, which will be held September 10, 11 and 12. Additional information can be obtained from exposition headquarters, Suite 759, 1 Gateway Center, Pittsburgh 22, Pa.

Sept. 11-13—

American Die Casting Institute. Annual Meeting to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from institute headquarters, 366 Madison Ave., New York 17, N. Y.

Sept. 12-14—

Porcelain Enamel Institute. Annual Meeting to be held at the Broadmoor Hotel, Colorado

Springs, Colo. Additional information can be obtained from institute headquarters, 1145 19th St. N. W., Washington 6, D. C.

Sept. 16-22—

American Society for Testing Materials. Second Pacific Area National Meeting and Apparatus Exhibit to be held at Hotel Statler, Los Angeles. Additional information can be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

Sept. 17-21—

American Society of Mechanical Engineers. Instruments and Regulators Division and Instrument Society of America Exhibit and Joint Conference, to be held at the Coliseum, New York. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 17-21—

Instrument Society of America. Eleventh Annual International Instrument - Automation Conference and Exhibit, to be held at the Coliseum, New York. Additional information can be obtained from society headquarters, 1319 Allegheny Ave., Pittsburgh 33, Pa.

Sept. 17-21—

Illuminating Engineering Society. National Technical Conference to be held at Hotel Statler, Boston. Further information can be obtained from society headquarters, 51 Madison Ave., New York 19, N. Y.

Sept. 23-26—

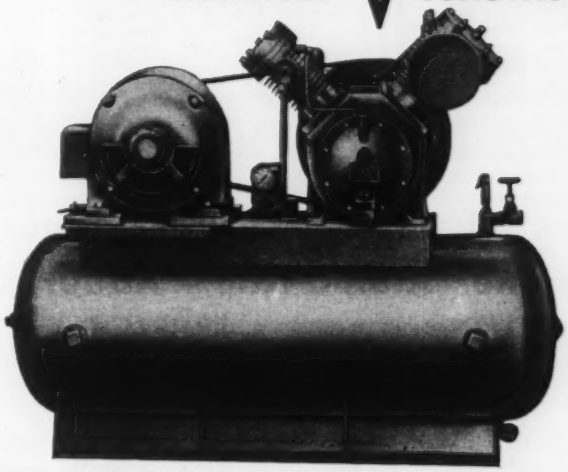
American Society of Mechanical Engineers. Petroleum - Mechanical Engineering Conference to be held at the Statler Hilton Hotel, Dallas, Tex. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 24-25—

Fifth Annual Industrial Electronics Symposium to be held at the Manger Hotel, Cleveland. Sponsors are Institute of Radio Engineers and American Institute of Electrical Engineers. Further information can be obtained from

A good point to consider...

BALANCED V CONSTRUCTION



Why the I-R Air Compressor is right for your product!

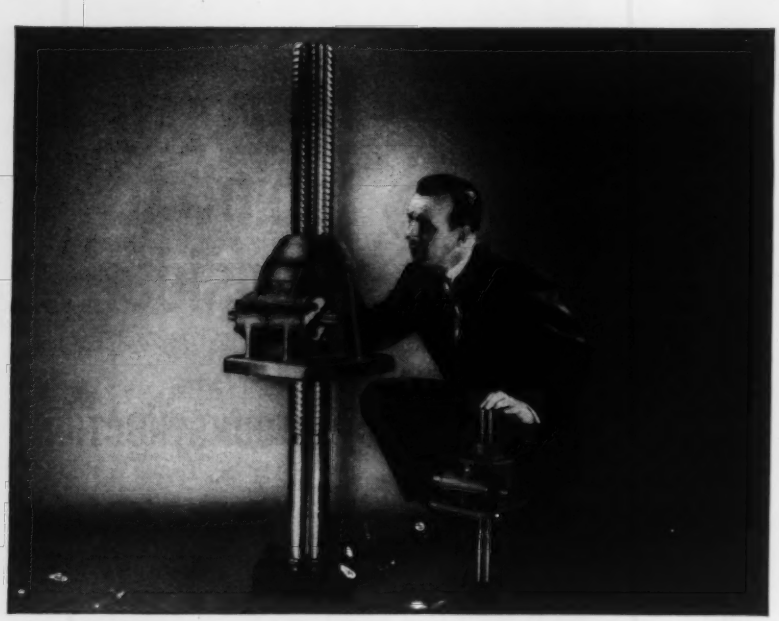
WHETHER YOU ARE DESIGNING equipment for your own operation or for resale, there are many points about Ingersoll-Rand's *Balanced V Construction* which will help maintain the quality of your air-powered product. These 3 advantages are typical:

1. **Dependable performance.** The I-R compressor is built to operate reliably, quietly, years longer.
2. **Efficient design.** It delivers more air-per-horse-power, size for size, than other compressors.
3. **Looks like Quality** . . . and it is! Compact, well-constructed, durably built, it carries the name and has the quality plant operators expect.

Get more detailed information on I-R Air Compressors—½ to 20 H.P.—to determine the advantages they bring to your own products. For prompt response, write to:

Ingersoll-Rand
3-352 11 Broadway, New York 4, N. Y.

—ITEM 516—



Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 96:1; turn of worm for each 1-inch raise, 10 to 180; available in either Acme or square threads. For protection against foreign matter certain models can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—overhead crane servicing.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes. For complete specifications and detailed drawings, send for your free copy of a special brochure.

DUFF-NORTON Company

DUFF-NORTON COMPANY
Department MD
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

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COMPANY _____ PHONE _____

ADDRESS _____

—ITEM 517—
For More Information Circle Item Number on Yellow Card—page 19

News Roundup

R. C. Rodgers, Associate Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Sept. 24-25—

Steel Founders' Society of America. Fall Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Additional information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, O.

Sept. 24-28—

Trade Fair of the Atomic Industry to be held at the Navy Pier, Chicago. Additional information can be obtained from Atomic Industrial Forum, 260 Madison Ave., New York 16, N. Y.

Sept. 25-28—

Association of Iron and Steel Engineers. Iron and Steel Exposition and Convention, to be held in the Public Auditorium, Cleveland. Additional information can be obtained from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Oct. 1-3—

National Electronics Conference and Exhibition to be held at the Hotel Sherman, Chicago. Sponsors are American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University and University of Illinois. Further information is available from conference headquarters, 84 E. Randolph St., Chicago 1, Ill.

Oct. 1-5—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Further information can be obtained from institute headquarters, 33 W. 39th St., New York 18, N. Y.

Oct. 2-6—

Society of Automotive Engineers Inc. National Aeronautic Meeting, Aircraft Production Forum and Aircraft Engineering Display to be held at Hotel Statler, Los Angeles. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

MEN

OF MACHINES

Frank M. Butrick Jr. has joined the staff of MACHINE DESIGN as an assistant editor. Mr. Butrick was formerly associated with Lobdell-Emery Mfg. Co. where, as a process engineer, he was in charge of

Frank M. Butrick Jr.

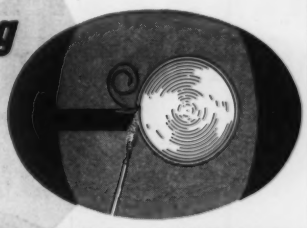
improving productivity and reducing costs. He is a member of the American Society of Tool Engineers, American Welding Society, American Electroplaters' Society and American Society of Naval Engineers.

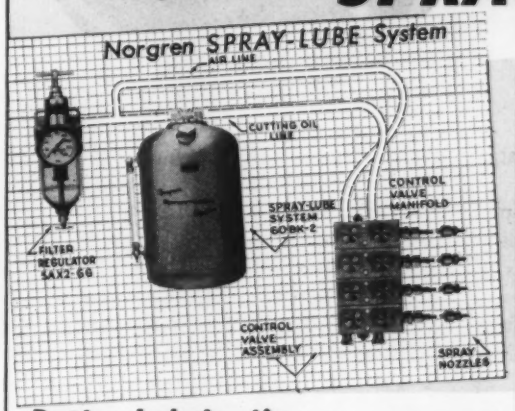
Charles A. Sereno recently was elected executive vice president of Air Associates Inc., Teterboro, N. J. Mr. Sereno joined the company eight years ago and has held various executive engineering positions.

The Gamewell Co., Newton Upper Falls, Mass., has appointed **Edward S. Ruth** to the position of chief engineer. Mr. Ruth joined the company in 1954.

The Research and Advanced Development Div. of Avco Mfg. Corp., Stratford, Conn., has announced two recent appointments. **Sidney L. Simon** has been named

Faster Metal Cutting at LOWER COST with improved Norgren SPRAY-LUBE





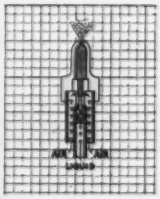
for
Tapping Machines
Drill Presses
Milling Machines
Grinders
Lathes
Boring Machines
High-Speed Saws
Stamping Presses
Die Lubrication
Other Metal Working Equipment

Better Lubrication—A better, more uniform spray of cutting oil is applied directly upon the close interface between the tool and work piece. It can be directed from the underside of the curled chip or from any other angle that will best reach the critical lubrication points. Tool wear is less—saves tool costs, cuts down-time.

Faster Cooling—Because of the larger fluid surface area of the spray and the expansion of the compressed air, heat is dissipated quicker. Cutting can be faster—production stepped up.

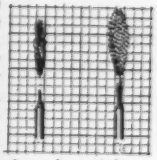
Uniform Spray

Air and cutting oil, with flow of each accurately controlled, are conveyed to the nozzle by means of a tube within a tube connection. The oil spray produced by the discnarge nozzle is consistently uniform in quality. The spray is delivered to the cutting area the instant the machine is turned on. There is no sputtering or intermittent flow.



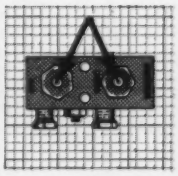
Accurate Control of Spray

By adjusting the pressure and the individual outlet controls for air and coolant, spray can be applied in exactly the right quality and quantity for any metal cutting or metal forming job.



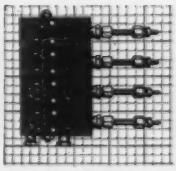
Tamper-Proof Controls

Allen-head screws are used on the control valves for adjusting flow of both air and liquid and are recessed into valve to prevent tampering with flow.



Valves Compactly Manifolded

For multi-point application of SPRAY-LUBE, the control valves are designed so that they can be closely assembled in a manifold arrangement.



Compact, Convenient Size

A space only 14"x20"x7" is required for a 2-gallon unit—4 to 12 fluid ounces of liquid an hour per nozzle are sufficient for most operations.

Norgren CA CO

3442 So. Elati St., Englewood, Colo

Without obligation, learn how improved Norgren SPRAY-LUBE can reduce costs in your plant. Call your nearby Norgren Representative listed in your telephone directory — or WRITE THE FACTORY FOR BULLETIN 537.

Pioneer and Leader in Oil-Fog Lubrication Since 1930

—ITEM 518—

ALBADURE*... the steel tape with lasting legibility

Here is a steel tape that stays clear and legible long after markings on other tapes have worn off.

An amazingly tough plastic coating on both sides of the line protects the white background, the graduations and numbers on ALBADURE tapes, giving their surfaces tremendous resistance to abrasion and corrosion. To quote a State surveying party report, "If ALBADURE stood up in this tough mud and sand, it'll stand up anywhere." Available in all standard lengths, widths and graduations, in cases and on reels.

PHOENIX WYTEFACE®... the woven tape that outlasts others 3-1

PHOENIX WYTEFACE (non-metallic) Woven Tapes made from extra strong synthetic yarns, are harder wearing, with higher tensile strength and dimensional stability than ordinary woven tapes. A special plastic coating on both sides protects the line against hard use, water, stones or brush.

The end of the line is enormously strengthened by a lamination of Flexi-Foam, a spongy plastic-rubber. No stitches or hinge point to weaken the line.

A Highway Engineer reported of the non-metallic PHOENIX WYTEFACE, "It has at least three times the life of an ordinary metallic tape." *Ask Your K & E Dealer!*

*Trade Mark

89 YEARS OF LEADERSHIP In equipment and materials for drafting, surveying, reproduction and optical tooling . . . in slide rules and measuring tapes.

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—ITEM 519—

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Men of Machines

director of applied research for the division and **James P. Kennedy** has been appointed manager of the Everett, Mass., research laboratory.

At the recent semiannual meeting of the American Society of Mechanical Engineers, **William F. Ryan** was nominated to serve as the society's president for 1956-57. He will be installed at the annual meeting in November. Dr. Ryan is vice president, director and senior consulting engineer of Stone & Webster Engineering Corp., Boston. He joined this firm in 1929

William F. Ryan

as a mechanical engineer and was named vice president in 1950, after having served as assistant chief mechanical engineer, assistant engineering manager, and engineering manager. He has been a member of ASME since 1917 and has served in numerous committee, divisional and delegate assignments for the society. Currently he is ASME representative on the EJC-ECPD Committee on Practice of Engineering, and is advisory member of the Power Division Executive Committee.

McDonnell Aircraft Corp., St. Louis, has established a research department and appointed **Albert E. Lombard Jr.** director of research to head the department. Dr. Lombard's work will supplement and contribute to work now being con-

ducted in the company's Airplane, Helicopter and Missile Engineering divisions and the Flight Department, which are engaged in the design and development of specific aircraft and weapon systems.

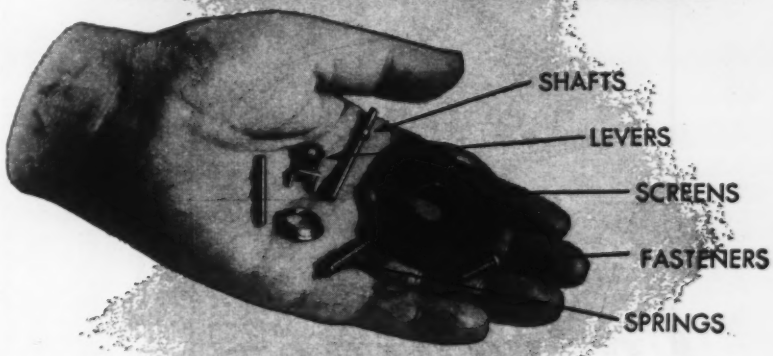
Jacques H. Mercier has been appointed products manager of the recently formed Greer Industries Inc., an affiliate of Greer Hydraulics Inc., Jamaica, N. Y. He had been assistant to the president and chief engineer of Greer and was previously associated with General Electric Co.

George A. Crowther recently was named chief engineer of Ford Instrument Co. division of Sperry Rand Corp., Long Island City, N. Y. Mr. Crowther will direct engineering division projects, including missile and weapon controls, air and sea navigational

George A. Crowther

equipment, and computing devices. He will report to **Dr. Charles R. Burrows,** recently appointed vice president of engineering. Mr. Crowther's previous affiliations include Mack International Motor Co. and International Safety Lock Nut Co. He joined Ford Instrument Co. as a designer in 1928 and advanced to design engineer, senior design engineer, assistant chief engineer and engineering director for marine equipment before his latest appointment.

ARE *small* PARTS CAUSING YOUR PRODUCT FAILURES?



It Will Pay You To Use ALLOYS

How many times can you trace your product failure to the corrosion, wear or breakage of some small part? A screw . . . a shaft . . . small spring . . . a gear or other seemingly insignificant part? In most cases the failure can be blamed on the material from which the part was made. The use of Nickel Alloys or Stainless Steel Wire, Rod or Strip for these parts could have saved many dollars in service and replacement costs because of their superior engineering properties.

How much more will alloy materials cost? Actually, on small parts, fabrication, finishing and other manufacturing costs will more than likely far overshadow material cost. You will find that the extra cost of using alloys will be insignificant compared with the benefits in longer service life, lower maintenance costs and fewer customer complaints.

For informative technical data on our alloys . . . and for some good ideas . . .

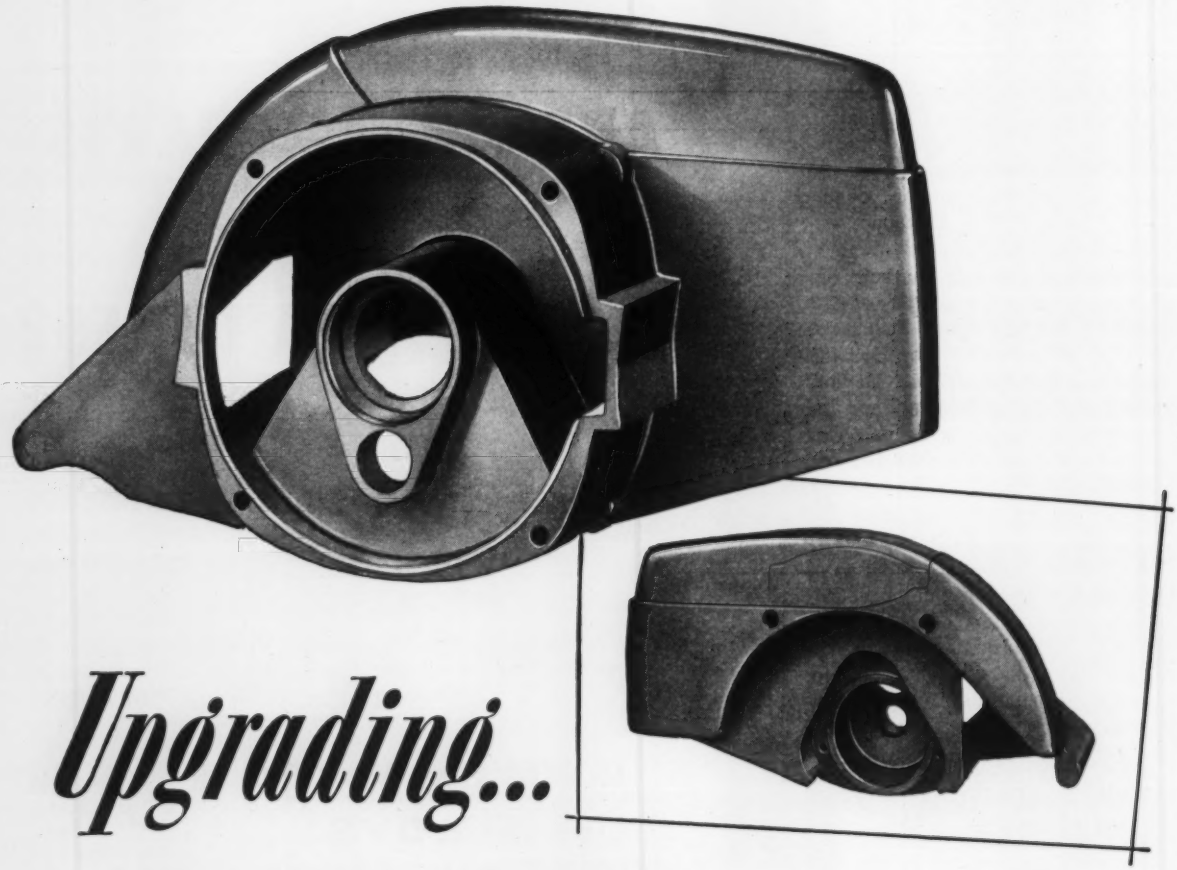
SEND TODAY FOR OUR NICKEL ALLOY AND STAINLESS STEEL DESIGN HANDBOOKS.

ALLOY METAL WIRE DIVISION

HKP H. K. PORTER COMPANY, INC.
Prospect Park, Pennsylvania

—ITEM 520—

For More Information Circle Item Number on Yellow Card—page 19



Upgrading...

with MADISON-KIPP zinc and aluminum die castings

Die casting as a process, has many inherent advantages in providing lightness, strength and stability in parts that can be cast to dimensions requiring a minimum of machining. These advantages have greatly assisted in upgrading many mass-produced products from automobiles to toys.

To get maximum process utilization, the seasoned and skilled mechanics at Madison-Kipp have proved very helpful to highly placed engineers and designers for over a quarter of a century.

Please clip this ad as a reminder to contact us when you have die casting requirements.

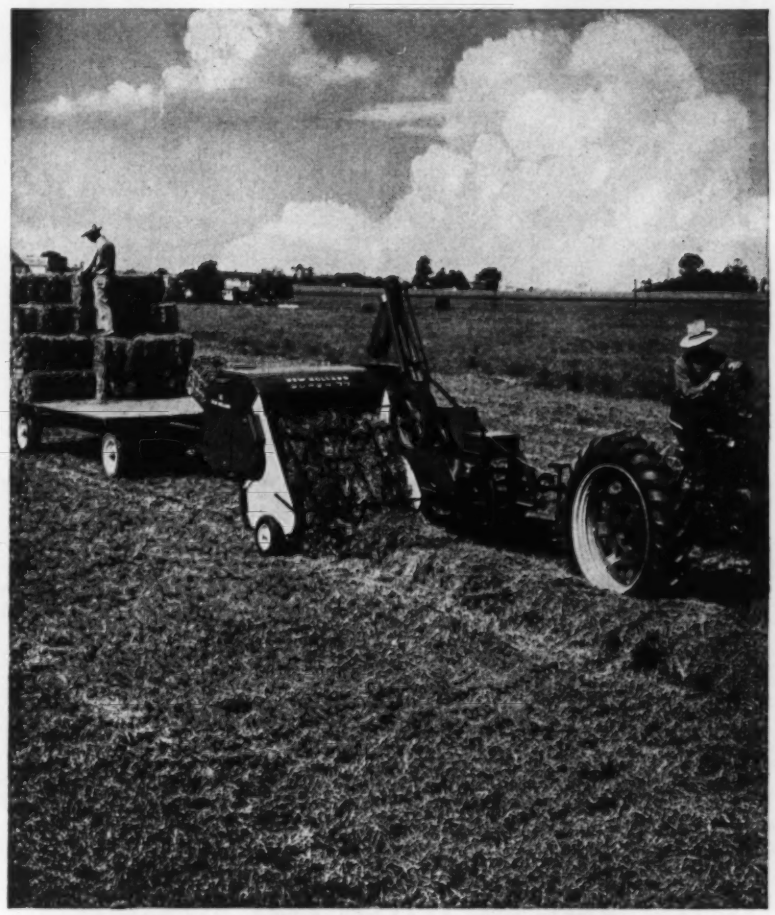
kipp

MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U.S.A.

• Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

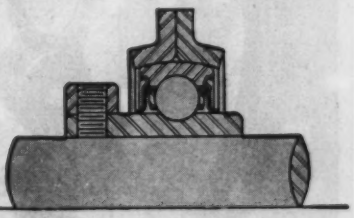
—ITEM 521—
For More Information Circle Item Number on Yellow Card—page 19

MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings



THIS NEW HOLLAND HAY BALER is typical of equipment on which JPS-200 ball bearing pillow blocks are popularly applied.

SELF-ALIGNING. Free-rolling and full load capacity of the JPS-200 ball bearing pillow block are maintained even with shaft deflection or misalignment.



MAXIMUM SEALING EFFICIENCY. Synthetic rubber lip-type seal, integral with bearing, keeps lubricant in, dirt out. Greased at factory ready for operation.

SINGLE-ROW, DEEP-GROOVE standard Series 200 ball bearing is used. Extra-long inner ring assures proper load distribution—heavy spring locking collar firmly secures bearing on shaft.

Low cost Compactness Self-alignment

Link-Belt JPS-200 ball bearings combine all three

HERE is a new concept in bearing design—a proven answer to the economy needs of many equipment manufacturers. And most important—this JPS-200 Series ball bearing pillow block achieves low cost without sacrifices in bearing design.

The standard, full-capacity, self-aligning Series 200 ball bearing is supported in a rugged, pressed steel housing. Further economies result because the JPS-200 arrives in *one piece*—ready for fast, foolproof installation. And standard dimensions plus extreme compactness are added aids to the designer.

Ask any one of 40 Link-Belt offices for Folder 2517 containing complete information on the JPS Series. And get Book 2550 for data on Link-Belt's complete ball and roller bearing line.

LINK-BELT

Ball and Roller Bearings

Rugged, steel-clad JPS-200 Series — from industry's most complete line of ball and roller bearing pillow blocks.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,988-A

—ITEM 522—

For More Information Circle Item Number on Yellow Card—page 19

NEW CRAMER INTERVAL TIMER features ¼ of 1% of full-scale repeat accuracy, offers wide time-range selection.

New automatic reset interval timer

Eleven full-scale time ranges—15 seconds to 24 hours—give new Cramer Type 241 versatility and precision.

Increased accuracy and operating convenience, a wide selection of time ranges, and lower costs to users are key features of the new Cramer Type 241 automatic reset interval timer.

The new Type 241 timer provides push-button starting and automatic shut-off after a predetermined time interval for a wide variety of electrically-operated equipment such as washing machines, mixers, ovens, tumbling and plating equipment, and laboratory and test equipment. Here's what it offers:

Wide selection of time ranges — 11 full-scale time ranges available ranging from 15 seconds to 24 hours.

Heavy-duty contacts — rated at 15 amperes, non-inductive load, provide capacity to handle high inrush currents.

High overall accuracy — within ± ½ of 1% of full scale, exclusive of human setting errors.

High repeat accuracy — within ± ¼ of 1% of full scale.

Easy-to-read 3-inch dial — a fully enclosed high-visibility, black-on-white dial features 300° scale, black setting pointer and red progress pointer for easy reading and accurate setting.

Easy interval setting — large setting knob, concentric with red start button, allows rapid setting to precise time intervals. And, important at longer time ranges, setting may be changed while unit is running.

You'll find complete data on the new Type 241 timer in Bulletin PB-211. Write for your copy today. The Cramer Controls Corporation, Box 6, Centerbrook, Conn. 6.4

OUR NEW NAME

The R. W. Cramer Company has become The Cramer Controls Corporation. The reason? Simply that we outgrew the old name. We're still specialists in precision time control. And, you'll find us today ready and willing to serve you with better products and faster deliveries than ever before.

The Cramer Controls Corporation, Centerbrook, Conn.

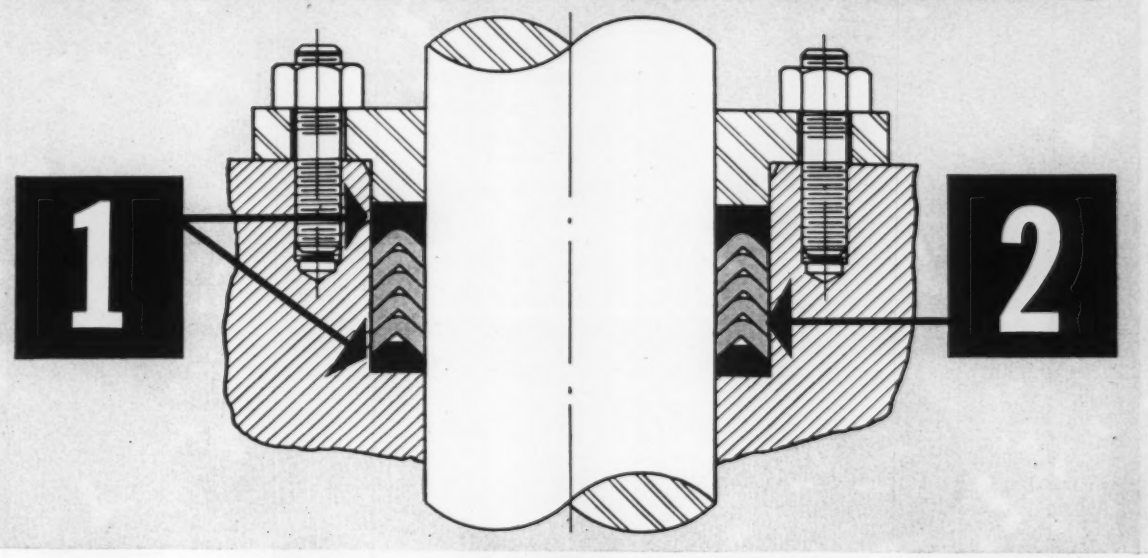
CRAMER CONTROLS

CORPORATION

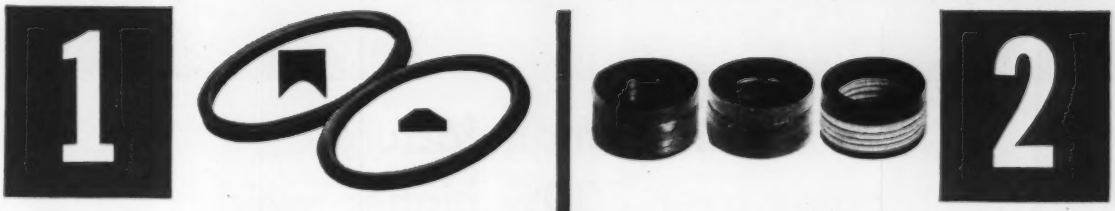
—ITEM 523—

For More Information Circle Item Number on Yellow Card—page 19

TWO NEW HOUGHTON "V" PACKING DEVELOPMENTS



SAVE TWO GLAND DESIGN JOBS



Houghton's new molded "V" Packing adapters do away with individually designed metal support rings. And besides saving you design work, they help "V" Packings make a better seal.

These molded rings can "give" under pressure, expanding to bridge the clearance. They'll flex without cracking. They're not subject to the fatigue that can break down metal rings. Because they expand along with packings Houghton Molded "V" Packing adapters provide better support and permit packings to give longer service.

Standard stack heights of Houghton "V" Packings give designers a break, too. When you use Houghton "V's" you don't need to design glands differently because packings of different materials will be used in them. Just figure the number of packings pressure requirements demand . . . then allow for the dimension in your design. Whether you use rubber, fabricated rubber, or leather "V's" . . . they'll fit. They are all the same stack height.

There's more than 50 years of hydraulic know-how behind these new design developments. They're typical of Houghton's complete line of hydraulic and pneumatic packings and hydraulic oils and fluids. For the full story, call your Houghton Man today—or write E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

"V" PACKINGS

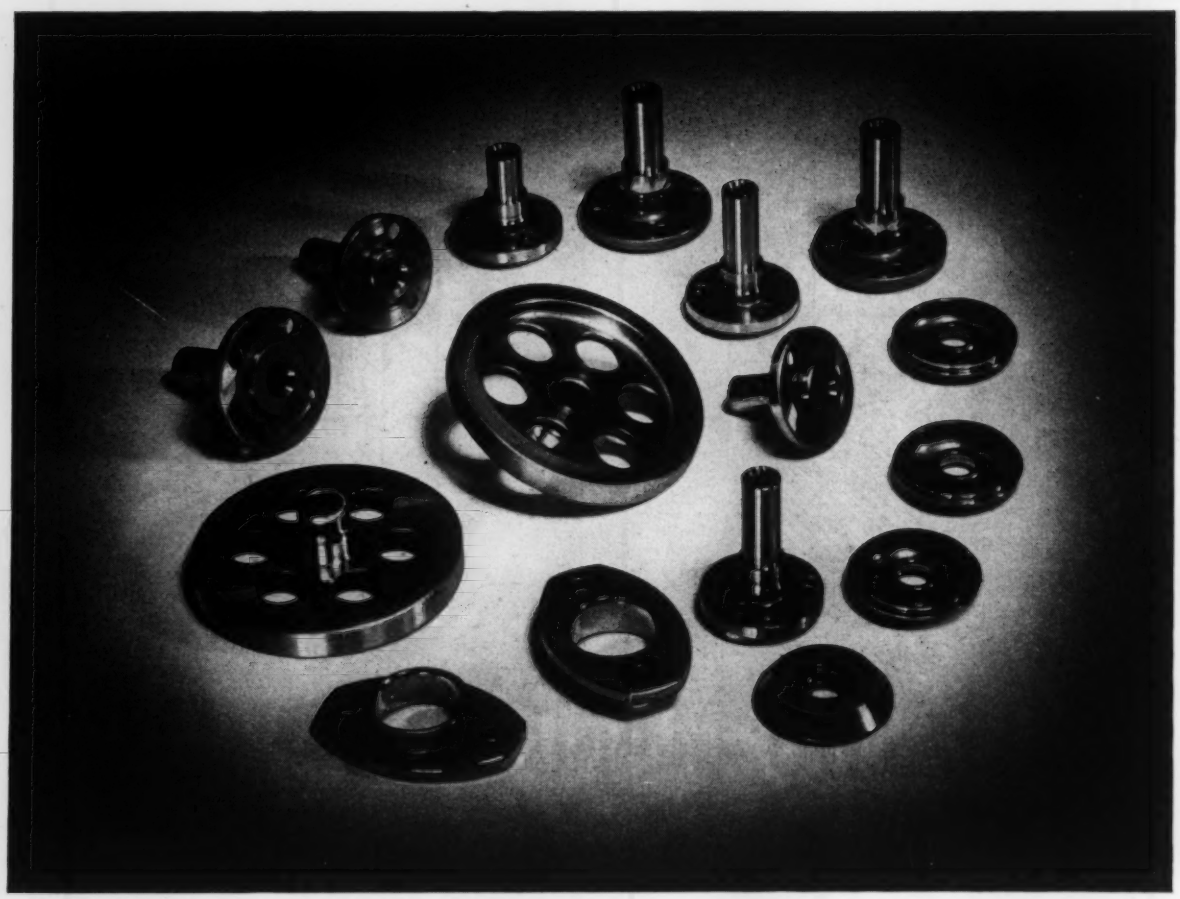
. . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

—ITEM 524—



bearing manufacturer gains over 300% higher yield with Vacuum Metals FERROVAC

Because a leading manufacturer of precision instrument bearings worked to such exacting standards, he experienced an exceptionally high rate of rejection of finished parts. Then they tried Vacuum Metals FERROVAC®... of the same basic analysis as the air-melted grade used previously. The results were decisive. Rejections were reduced to less than 1% – a yield improvement of better than three times.

That's to be expected from vacuum-melted alloys, because of their remarkable uniformity. Gases that cause inclusions and that in turn lead to rejection – or early bearing failure – are literally sucked from vacuum-melted alloys during production... before the metal becomes solid.

The result is a *clean* alloy – with many of its properties improved. It is stronger, tougher, far more resistant to wear and fatigue. It works longer and harder than conventionally-melted alloy – even does the super-tough jobs where *nothing else* will work.

Only Vacuum Metals gives you one-source service – Vacuum Metals' own large organization, and its affiliation with National Research Corporation and Crucible Steel Company of America, brings you a fully integrated service. It includes everything from melting and casting, through mill rolling and nation-wide distribution of finished products. If you have an application where you can use vacuum-melted metals – in experimental lots or production quantities – Vacuum Metals can serve you. Write us now, outlining your requirements. *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, New York.*

VMC

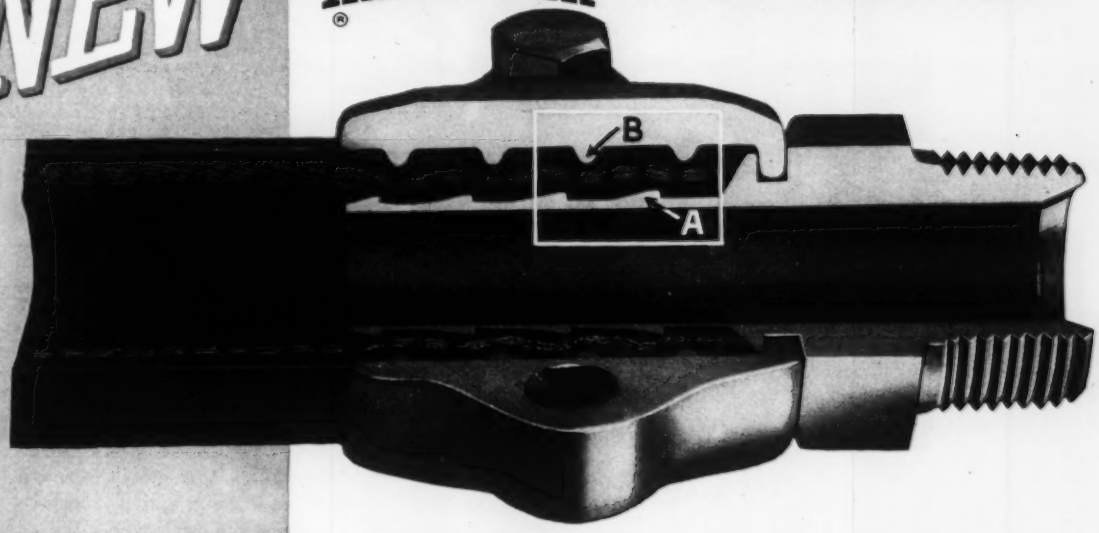
VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation

—ITEM 525—

For More Information Circle Item Number on Yellow Card—page 19

NEW Eastman INTER-LOCK® CLAMP COUPLING



EASTMAN MFG. CO. announces its New **Inter-Lock** Clamp Coupling—offering *exclusive grip advantages* available in no other coupling of its type.

EXCLUSIVE EASTMAN INTER-LOCK FEATURES

Eastman's New **Inter-Lock** Clamp Coupling provides positive positioning through accurate machining of clamp and insert—as the outside rib of the clamp is locked between the collar and hex of the insert, before tightening.

The accurate location of the clamp over the insert assures alternate mating of the barbs of the insert (A) with the circular ribs of the clamp (B).

Hose is uniformly compressed into each alternating recess—increasing the holding power of the Clamp Coupling—thereby creating **Eastman's Exclusive Inter-Lock Grip.**

Longer service is assured because hose construction is not weakened by pinching, as it may be if ribs and barbs were permitted to fall directly opposite each other.

EASTMAN'S Exclusive **Inter-Lock** feature is another example of advanced design and engineering which gives you greater value, plus the *all-important competitive advantage* of superior product performance and customer satisfaction in the field.

Look to EASTMAN . . . *first in the field* of Hydraulic Hose Assemblies . . . for continued leadership in design and engineering—plus the highest quality material and workmanship.

STANDARD INSERTS FOR EASTMAN INTER-LOCK CLAMP COUPLING

For low, medium and high pressure hose up to 5000 psi. working pressure. Available for hose sizes ranging from ¼" to 2" I.D.—according to pressure requirements. Also available for angle and straight tube applications.

SWIVEL FEMALE

MALE PIPE

MALE FLARE

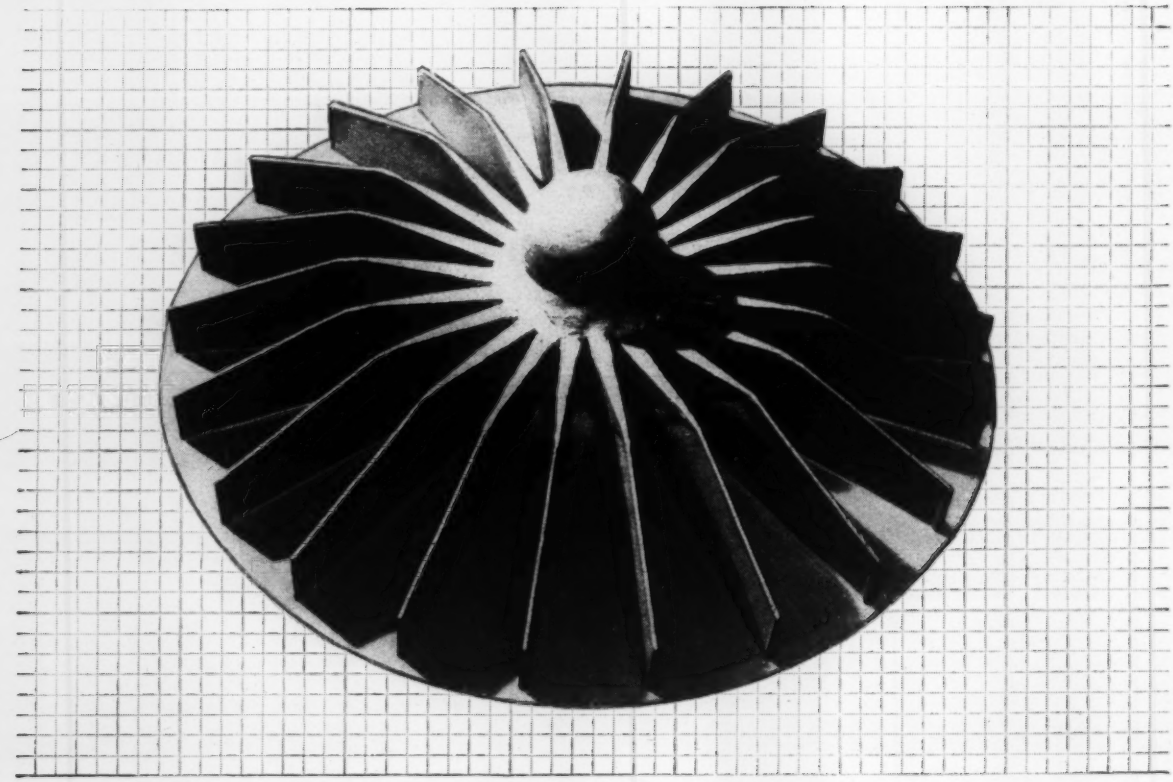
INSERT FEATURE
Serrated shoulders of barbs permit easy insertion into hose.

WRITE for Standard Sizes or send your blueprints and specifications.

SAFEGUARDING INDUSTRY'S *Lifelines of Mobile Power*

Eastman
first in the field
MANUFACTURING COMPANY
Dept. MD-8, Manitowoc, Wis.

—ITEM 526—
For More Information Circle Item Number on Yellow Card—page 19



22-inch Diameter Wheels Investment Cast . . . at a 50% Saving

Turbine wheels, 22 inches in diameter and weighing close to 100 pounds, are now being mass-produced by HAYNES' precision-investment-casting process. The wheels are made of stainless steel and are used in the turbocharger section of a compressor. At one time a lengthy profile machining operation was needed to shape the intricate blades. Investment-casting eliminated this operation and cut production costs in half.

The savings realized on this wheel are typical of the many economies made possible by HAYNES' precision-investment-casting process. This modern mass-production method eliminates many machining, grinding, and assembling operations. Intricate contours, odd-shaped cavities, and thin edges can all be cast to size. Two or more parts can be designed and produced as one integral part. In most instances, an investment-cast part can be placed in operation as soon as it is delivered.

For information on how you can use HAYNES' investment-casting process to keep production costs down, write to any of the District Sales Offices listed below.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works: Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.

—ITEM 527—

For More Information Circle Item Number on Yellow Card—page 19

New ASCO 3-Way Solenoid Valve assures MILLIONS OF TROUBLE-FREE OPERATIONS

NO EQUAL IN SIMPLICITY!

Simplicity is the secret of this remarkable, new 3-way diaphragm valve. It has *only three operating parts.* Compare this with the larger number of parts found in conventional 3-ways! That's one reason why the new ASCO valve means trouble-free operation . . . substantial savings in maintenance costs . . . reduction in down-time losses.

SIMPLICITY IN OPERATION

Not only its construction but also its new operating principle is the essence of simplicity: solenoid piloting of two simple diaphragms.

UP TO 400 CYCLES PER MINUTE

Exceptionally large flow capacity makes rapid recycling feasible . . . cylinders fill and vent rapidly . . . valve operates up to 400 cycles per minute over millions of strokes.

CONVERTS IN 30 SECONDS

Developed for dependable control of liquids and gases, the valve can be converted from normally open to normally closed or the reverse by simple rotation of the valve bonnet.

This new valve is absolutely tight seating . . . no closely fitted parts or valve seat grinding required. Available now in ⅜" and ½" pipe sizes, both with full ⅝" orifices, it can be mounted in any position.

WRITE NOW for your copy of ASCO Bulletin 8316, or have the ASCO Engineer call.

The EXTRA HEAVY FORGED BRASS BODY houses only three moving parts: Two diaphragms and a core. Corrosion protection is assured. All parts in contact with fluids or gases are brass, stainless steel or Buna-N.

ASCO

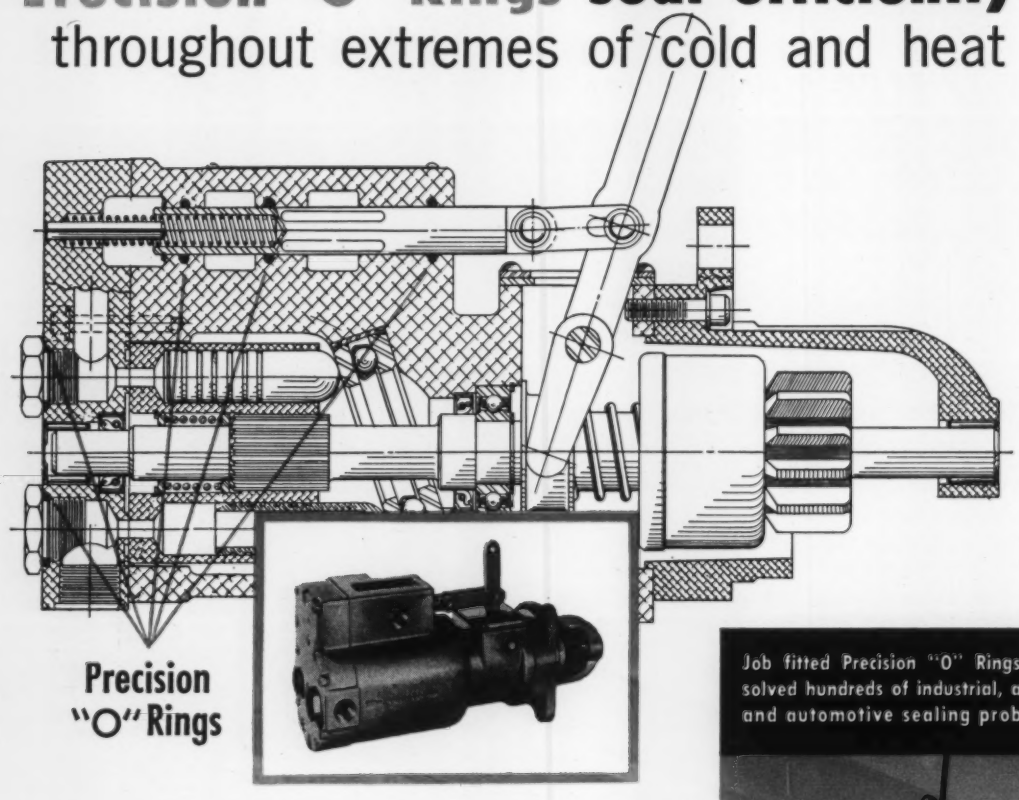
DEPENDABLE CONTROL

Automatic Switch Co. • 387 N. LAKESIDE AVENUE • ORANGE, NEW JERSEY

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

—ITEM 528—

Precision "O" Rings seal efficiently throughout extremes of cold and heat



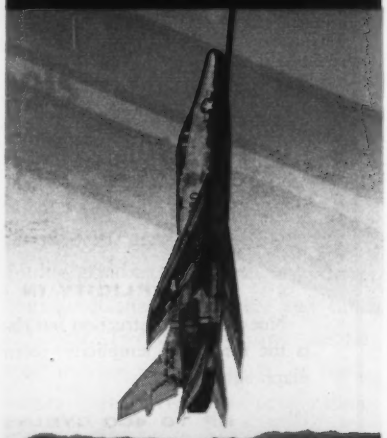
The Hydrotor Hydraulic Cranking Motor, manufactured by Hydramotive, Inc., Cleveland, Ohio, provides high cranking torque and adjustable speeds over a temperature range of −65° to +165° F.

Hydramotive, Inc., standardized on Precision "O" Rings after exhaustive competitive tests. Precision "O" Rings guaranteed long life sealing and flexibility in arctic cold.

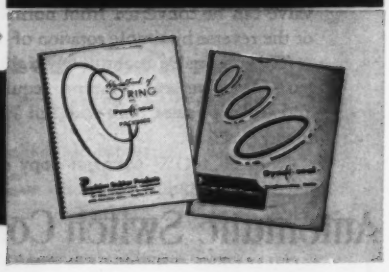
Precision "O" Rings are compression molded from quality controlled compounds. They're the finest made! Rigid inspection and engineering skill assure long life, leak proof sealing. Precision can furnish the size and compound that fits your requirements and "O" rings that meet all military and commercial specifications.

What is your sealing problem? There is an expert—the Precision engineer—ready to help you in product design. Rely on Precision, the world's largest exclusive producer of "O" rings.

Job fitted Precision "O" Rings have solved hundreds of industrial, aircraft and automotive sealing problems.



Precision "O" Rings meet military specifications and were used in the North American F-100C Super Sabre.



Write for your free copies of Precision catalogs on "O" Rings and Dyna-seals

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

Dept. 9, Oakridge Drive, Dayton 7, Ohio

Canadian Plant at: Ste. Thérèse de Blainville, Québec

—ITEM 529—

For More Information Circle Item Number on Yellow Card—page 19

Now! Bruning Makes Tracing Cloth a Practical, Economical Medium for Everyday, Every Job Use!

Improved All-Purpose No. N378 "Whitney" Tracing Cloth

- Resists Liquids and Solvents!
- Takes Pencil up to 9H Hardness!
- Erases Easily and Cleanly!

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Two Improved Special-Purpose Cloths

No. 370 "McKINLEY"

Primarily designed for pencil, this modern cloth stands unequalled by any product of its type for durability and reproduction performance! It readily takes pencil hardness up to 8H. Blue or white.

No. 375 "GUIL-TRACE"

Exclusively designed for ink, this new and better cloth is unmatched for its superb acceptance of ink, maximum contrast in printing, top reproduction speed. Blue only.

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Here it is! The truly modern and wonderfully improved all-purpose tracing and drawing cloth that you can use *profitably* for every job in your drafting room!

This remarkable cloth just can't be damaged by perspiration, spilled drinks, or repeated use of regular drafting room solvents. It readily accepts pencil *up to 9H hardness*, can also be used with ink. Its completely clear body, high translucency, and high permanence assure sharp, good-looking tracings and drawings that produce fine prints, even after long periods of storage.

No tracing or drawing medium could be more economical or practical! You get good results every time—minimize the constant danger of damage to costly drawings. You speed draftsmen's work, get faster reproduction. You can use this versatile cloth for every tracing and drawing job in your drafting room, simplify and save on purchasing, stocking, and inventory of materials.

Try this all-modern, all-purpose tracing and drawing medium. Here is the smallest cost going into a tracing or drawing, but one of the most important. Send today for your free 8½ x 11-inch sample sheet. Blue or white.

BRUNING

America's Leading Supplier of Engineering and Drafting Equipment.

CHARLES BRUNING COMPANY, INC., 4700 MONTROSE AVE., CHICAGO 41, ILL.
In Canada: Charles Bruning Company (Canada) Ltd., 105 Church St., Toronto 1, Ont.

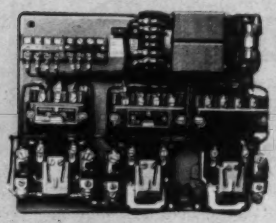
Charles Bruning Company, Inc., Dept. 84-K
4700 Montrose Ave., Chicago 41, Illinois

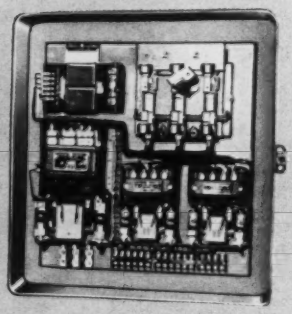
Please send me my 8½ x 11-inch trial sheet of
☐ All-purpose "Whitney" No. N378 ☐ "McKinley" No. 370
☐ "Guil-Trace" No. 375

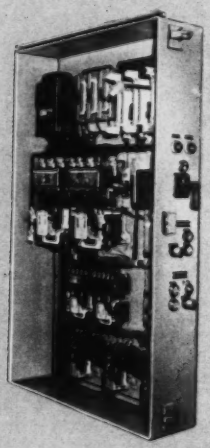
Name _____ Title _____
Company _____
Address _____
City _____ Zone _____ State _____

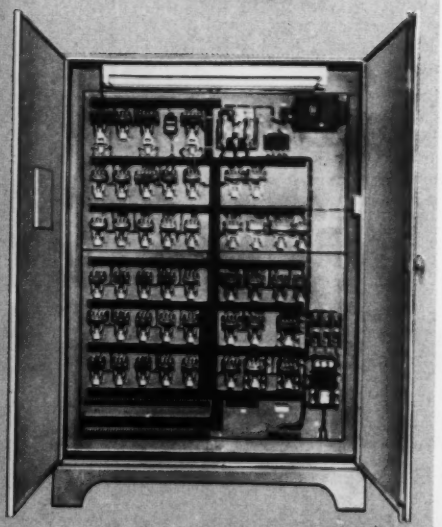
G-E general purpose control on

TYPICAL PANELS









NEW HIGH PRODUCTION GRINDER EQUIPPED WITH G-E CONTROL HOLDS 15 MICROINCH FINISH

This new Van Norman Bowgage Production Grinder is designed for high production grinding of any part that can be readily chucked. The grinder can remove 0.022-inch on a 1⅝-inch diameter piece, hold a 15 microinch finish, and with operator initiated automatic clamping can have a new piece ready for grinding every 15 seconds.

Manufactured by the Van Norman Machine Co., Springfield, Mass., the Bowgage Production Grinder provides the equivalent of two Single Head Production Grinders on a single base. This reduces the floor space required, operator fatigue, handling time, and maintenance.

machines for industry

NEW G-E PAN-A-TROL* PANELS

A new program for packaged machine control from General Electric

Pan-A-trol panels are the focal point of a new program from General Electric for packaged machine control. This program, which places a new emphasis on panels for the dynamic automation age, features outstanding service to customers. The Pan-A-trol name distinguishes these panels which are applied to machines with a maximum rating of 200 horsepower, 600 volts, a-c.

This new program emphasizes the General Electric services available to you with Pan-A-trol packaged control. An enlarged engineering staff is ready to work with you on developing a circuit and panel design to meet your machine requirements. These G-E engineers can also help you take advantage of cost reductions due to repetitive or quantity Pan-A-trol orders.

Faster and better factory service is provided by expanded manufacturing facilities. Up-to-date equipment and skilled employees assure you of fast, prompt shipment. And, of course, General Electric's field service organizations assure your customers of fast local service if desired.

PAN-A-TROL NAMEPLATE identifies each panel. Built from your specifications, these panels offer you the installation, maintenance, and reduced stocking benefits of packaged control.

See your G-E Apparatus Salesman about this new program, and let him tell you how you can benefit from Pan-A-trol packaged control. **And, write Section 731-3 for bulletin GEA-6334.** General Purpose Control Department, General Electric Company, Bloomington, Illinois.

*Reg. trade-name of General Electric Co.

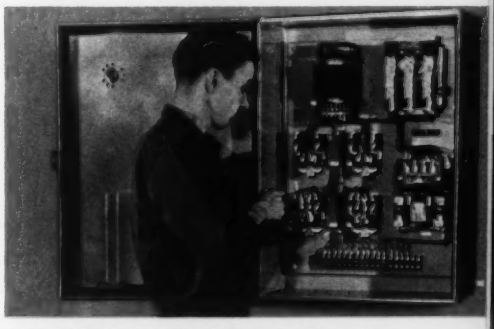
Progress Is Our Most Important Product

GENERAL ELECTRIC

4 WAYS TO BENEFIT WITH PAN-A-TROL PANELS

ENGINEERING ASSISTANCE. An enlarged staff of General Electric engineers in the factory and local offices are ready to help you with Pan-A-trol panels for specific applications.

MANUFACTURING FACILITIES. Skilled employees in new, enlarged factory facilities with the latest manufacturing methods assure fast, prompt shipment for Pan-A-trol control panels.



UNIT DESIGN. Pan-A-trol packaged control combines circuit design, device selection and arrangement into one coordinated unit. Only connections to rest of machine need be made.

PAN-A-TROL QUALITY. High-quality components and construction, backed by General Electric's field services, assure long dependable performance with Pan-A-trol packaged control.

AMPCO — ONE-SOURCE SERVICE FROM RAW MATERIAL TO FINISHED PRODUCT

Only your

imagination

limits the ways you can use Ampco Alloys

That . . . and the requirements of the part you're designing

Should your part be sand-cast, centrifugally cast, shell-molded, precision-cast, forged, fabricated or extruded?

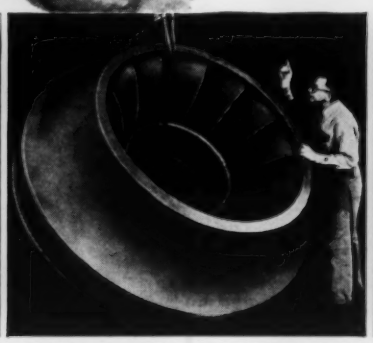
Let an Ampco field engineer help you to select the best, most economical form of production. It's all part of Ampco's one-source service to industry.

And he can help you select the best alloy, too. For among more than 100 Ampco copper-base alloys is the one you need to do the job — to resist wear, corrosion, impact, fatigue — to provide excellent bearing qualities — to retain physical characteristics at temperatures from 600°F down to −400°F.

So call in your Ampco field engineer and get his unbiased recommendations.

Write for Bulletin 33. D-53

5,400-lb. centrifugal casting for flywheel of a marine engine. Ampco makes centrifugal castings from a few pounds to five tons.

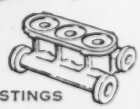


12,000-lb. sand-cast water wheel. Ampco's sand foundry makes any-size casting to 14,000 pounds — sand, shell moldings, cast-to-size, cement.

Ampco's one-source service includes production-run machining of Ampco copper-base alloys to the exacting quality standards of the aircraft industry.

AMPCO METAL, INC. Dept. MD-8, Milwaukee 46, Wisconsin • West Coast Plant: Burbank, California

AMPCO® **THE METAL WITHOUT AN EQUAL**



SAND CASTINGS

SHELL-MOLDED CASTINGS

CENTRIFUGAL CASTINGS

EXTRUSIONS

FABRICATIONS

SHEET AND PLATE

CAST-TO-SIZE CASTINGS

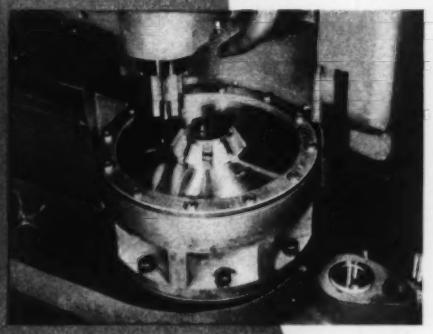
FORGINGS

MACHINED PARTS

—ITEM 532—

For More Information Circle Item Number on Yellow Card—page 19

How Gear Shaper *Versatility* helps IMPROVE DESIGN

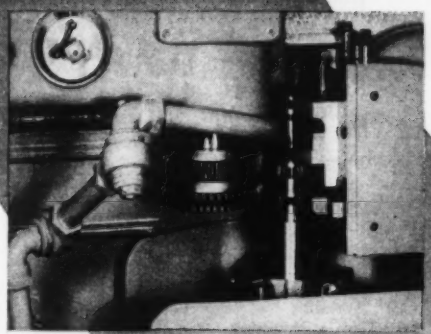


Quick-acting, air-operated diaphragm chuck speeds loading and unloading of pump rotor on Fellows No. 7A-Type Gear Shaper.

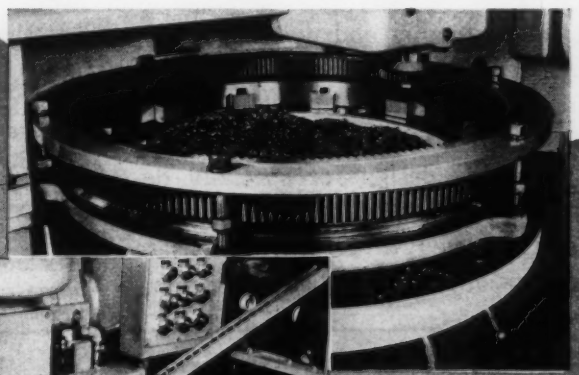
The Gear Shaper principle of generating with a reciprocating tool provides a versatile and economical method of manufacture which allows the engineer much greater latitude in the design of parts for low cost production. Special fixtures and controls permit cutting gears, intricate contours and other shapes in tandem or combination where otherwise, special-purpose machines might be required.

Free booklet — "The Art of Generating with a Reciprocating Tool" — shows in engineering detail how you can use Fellows Gear Shaper versatility to simplify and improve design. Write for it now.

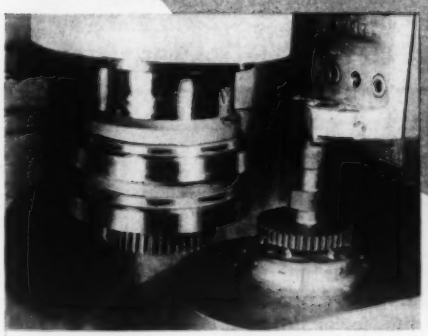
THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices: 319 Fisher Building, Detroit 2
5835 W. North Ave., Chicago 39
150 W. Pleasant Ave., Maywood, N. J.
6214 W. Manchester Ave., Los Angeles 45



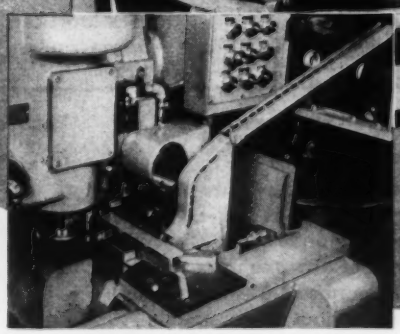
Two Gear Shaper Cutters in tandem cut automotive gears simultaneously. Center support fixture holds part in No. 4GS Gear Shaper.



Special fixture holds combination internal-external gear while internal gear is cut on 36-Type Gear Shaper.



Two cams and one gear are cut simultaneously on a gasoline motor part. Center support fixture holds part in No. 4GS Gear Shaper.



Fixture for automatically loading and unloading automotive pinions on the No. 4GS Gear Shaper.

THE PRECISION LINE **Fellows** *Gear Production Equipment*

—ITEM 533—
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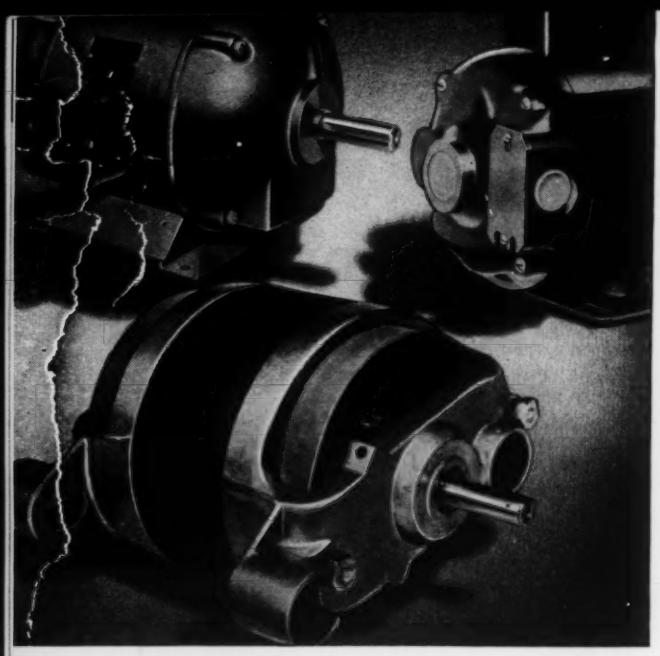


Complete Motors... or Motor Parts

Let your design problem make the choice!

Standard motors and matched motor parts represent only the beginning of what R & M is qualified to build! Special R & M fractional-horsepower with *any* housing design—or specially designed motor parts to fit your housings—are regular R & M contributions to products such as those listed at right:

Portable Saws	Vacuum Cleaners	Portable Grinders
Drills	Files	Sirens
Nut Setters	Sanders	Hair Driers
Hammers	Pumps	Advertising Devices
Routers	Compressors	Ventilating Equipment
Screw Drivers	Hones	Oil Burners
Hedge Trimmers	Business Machines	Surgical Instruments
Lawn Mowers	Cast Cutters	Grease Guns
Nibblers	Food Mixers	Vibrators
Lock Mortisers	Polishers	Die Sinkers
Valve Grinders	Planers	Waxers

The machine that tests motor performance . . . in minutes instead of months!

Formerly it took months to do a really thorough job of calculating motor performance and requirements for a given job. Now, using the unique R & M "Electrical Slide Rule," the performance of any one motor design can be calculated in about 20 minutes! Result? R & M can engineer a motor to your exact requirements . . . thoroughly, accurately, *and in time to meet your production and marketing schedules!*

You can expect quality . . . from every Robbins & Myers motor!

Here, for example, are some of the quality features built into R & M universal motor parts:

1. Every field coil has paper in the slots—in addition to standard taping. More insulation means longer motor life, fewer failures.
2. Insulating material is selected for the job. For example, glass insulated wires are used in sander and saw motors.
3. R & M motors are varnish-dipped and baked—as much as *three times* when service requires it.
4. Standardized commutators and laminations—for mass-production at no sacrifice in quality.
5. Diamond-turned commutators . . . for greater concentricity and smoother surface finish. Brushes last longer!
6. Matched Motor Parts are precision-built, 100%-tested, dynamically balanced, fully interchangeable.

How to select the best Fractional Horsepower Motors FOR MACHINES, POWER TOOLS, APPLIANCES

The most important single factor in motor performance is *selection* of the right motor for the job. That's why R & M offers such a wide variety of types and sizes of motors and motor parts. From these many standard and special-standard types we can, in most cases, help you select the motor to help give your product the best all-around performance.

We Also Custom-Design, Economically!

Your problem may require a custom-designed motor. If so, we'd much rather work out a special motor for you than see you take an "off-the-shelf" compromise.

Ordinarily the extensive calculations required make custom-designing pretty expensive. We've licked that problem, too, with the unique R & M "Electrical Slide Rule." This is an electrical motor-performance calculator. With it, the designer can reduce the work of a whole day or two to about twenty minutes! Naturally you and we both benefit.

Some Other Advantages of R&M Motors

R & M offers some special construction features: extra insulation; glass insulation where heat requires it; diamond-turned commutators; extra varnish treatment; a gratifyingly low failure rate.

As a pioneer in the small motor field, we have designed and built millions of small motors for thousands of different applications. And so we naturally feel well qualified, with engineering skill and experience, and extensive manufacturing facilities, to do an exceptionally good job for you. At least, it won't cost you anything to find out.

Let Us Tell You More

Call the nearest branch office for an R & M Motor Specialist—or write us for the information in which you are interested. Use the check list below.

MD

ROBBINS & MYERS, INC., MOTOR DIVISION,
Springfield 99, Ohio:

Please send me, without obligation, information on:

- ☐ Motor Parts for Portable Tools
- ☐ Universal Motors
- ☐ Capacitor Motors
- ☐ Universal and DC Motors
- ☐ R & M "All-Weather" Motors—up to 200 HP
- ☐ Please have a Motor Specialist call

Product we manufacture: _____

Name _____ *Title* _____

Company _____

Street _____

City & State _____

R&M MAKES BOTH!
Fractional horsepower motors and parts . . . from 1/200 h.p.

If it's an R&M, it's the Right Motor!

Integral Horsepower motors; famous R&M "All-Weather"* motor with sealed bearings. Up to 200 h.p.

**"All-Weather" is an R&M trademark*

ROBBINS & MYERS, INC.

SPRINGFIELD 99, OHIO • BRANTFORD, ONTARIO

Fractional & Integral h.p. Motors & Generators

Electric Fans

Electric & Hand Hoists & Cranes

Moyno Pumps

Propellair Industrial Ventilating Equipment

—ITEM 534—

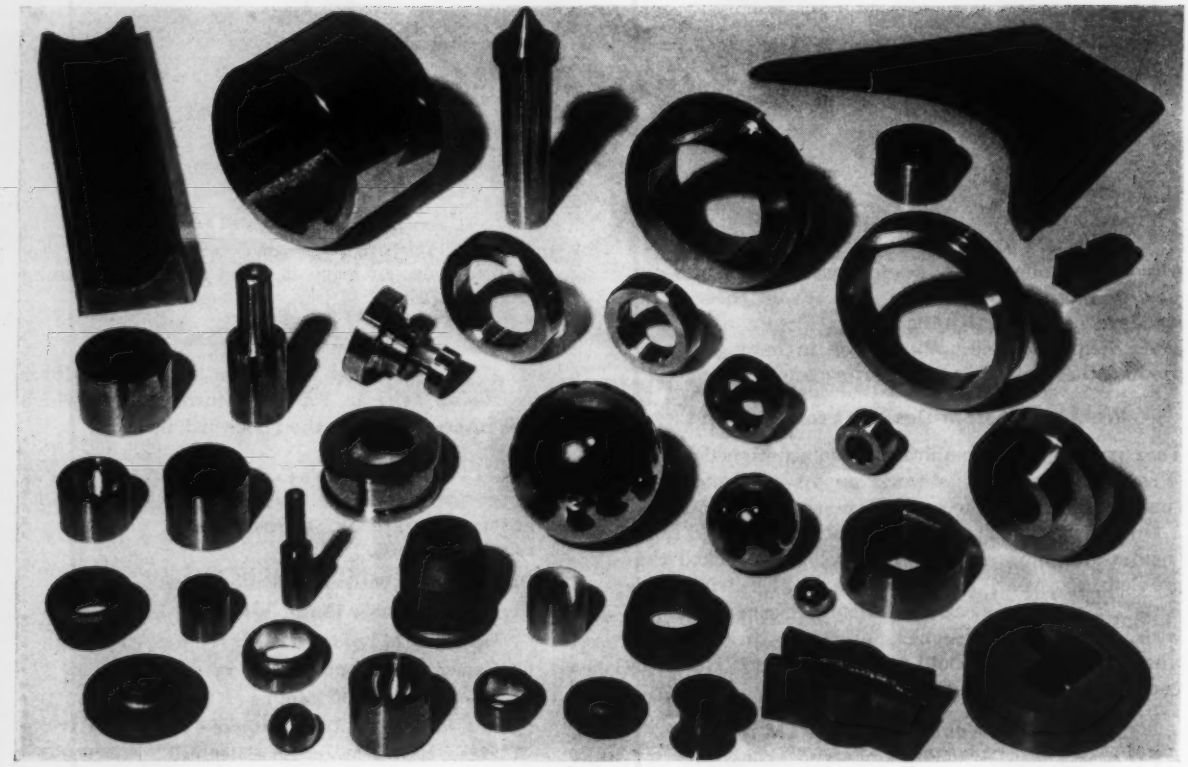
For More Information Circle Item Number on Yellow Card—page 19

choose

REXALLOY

cast

parts



for

high strength • corrosion and abrasion resistance • fine finish

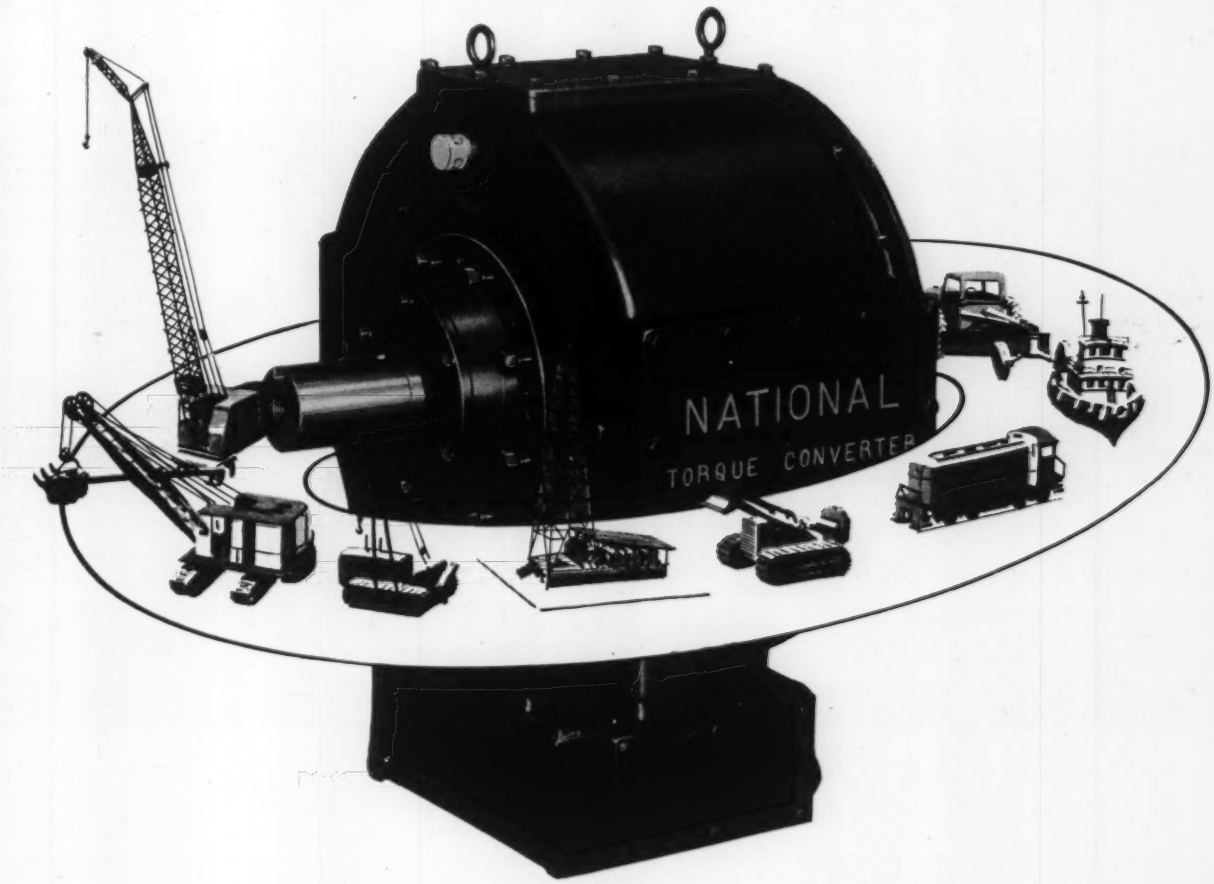
When high-hardness—even at elevated temperatures—resistance to corrosion and abrasion, and smooth, clean finish are important—Crucible REXALLOY® can't be beat. It's a chromium-tungsten-cobalt base nonferrous alloy.

What's more, REXALLOY parts can be produced to close tolerances, in almost any shape, by either investment, sand, or the new shell-mold casting process. Finishing operations are practically eliminated—costs substantially reduced.

Check on the advantages one of the many types of REXALLOY castings has for your product. Your Crucible representative will give you all the facts. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America



a star performer where top performance is needed

National Torque Converters are designed to help your equipment provide top performance where top performance is required . . . in strip mining, mechanized mining, drilling, earth moving, road building, load lifting and transportation, logging operations, and similar industrial applications . . . wherever Diesel or gas engines or electric motors are used.

The torque converter transmits engine power to the job in a steady, smooth flow. All the shock of quick starting and fast acceleration of the load is absorbed hydraulically by the torque converter. This enables the engine to attain its optimum speed quickly . . . without lugging or stalling . . . and to deliver its full horsepower constantly.

The result: Your equipment will do more work or jobs per unit per operator per day . . . job cycles will be completed faster . . . engine life will be extended with less maintenance.

You have a choice of 6 basic hydraulic circuit sizes, each with a range of input ratings, to permit *exact matching* of torque converter to engines or motors of 100 to 1000 horsepower in practically every heavy-duty industrial application . . . on all power equipment—power shovels and drag lines, shovel loaders, cranes, drilling rigs, graders, logging equipment, and the like.

Our engineers will gladly discuss the application of National Torque Converters to your power equipment and make recommendations of exact size and torque capacity. Why not call on us?

Ask for a copy of our Bulletin No. 468.

THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission

—ITEM 536—

Let all these sealing engineers help you design-in oil seals

Why "do it yourself?" Why chance the wrong seal? Why risk costly retooling or remanufacture because an unforeseen condition rendered an oil seal helpless?

The finest oil seal counsel anywhere is yours for the asking. Just pick up the phone and call the nearest National Oil Seal Engineering office. You'll get complete, current information on newest seal developments, plus the help of the entire National Oil Seal Engineering group. Field and factory, these men devote their entire lives to seals. They have seen literally thousands of sealing problems through to a successful solution.

Let National's three decades of sealing experience help you. Call now.

Specify seals at the drawing-board stage—always!

NATIONAL MOTOR BEARING CO., INC.

Plants at Van Wert, Ohio, Redwood City, Downey, Long Beach, Calif.

General Offices at Redwood City

CHICAGO, ILL. . *Room 462, McCormick Building, HArrison 7-5163*
CLEVELAND, OHIO . *210 Heights Rockefeller Bldg., YEllowstone 2-2720*
DALLAS, TEXAS . . . *2520 West Mockingbird Lane, DIxon 7541*
DETROIT, MICH. . . . . *13836 Puritan Avenue, VErmont 6-1909*
DOWNEY (Los Angeles Co.), CALIF. . *11634 Patton Rd., TOpaz 2-8163*
INDIANAPOLIS, INDIANA . . *2802 North Delaware St., WAlnut 3-1535*
KANSAS CITY, MISSOURI . . . . . *4445 Terrace, LOgan 6622*
MILWAUKEE, WIS. . . *647 West Virginia Street, BRoadway 1-3234*
NEWARK, N. J. . . . . *1180 Raymond Blvd., MItchell 2-7586*
REDWOOD CITY, CALIF. . . *Broadway and National, EMerson 6-3861*
WICHITA, KANSAS . . . . *519 South Broadway, AMherst 2-6971*

3879

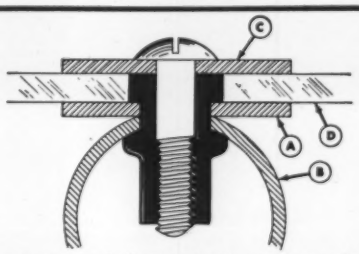
—ITEM 537—

For More Information Circle Item Number on Yellow Card—page 19

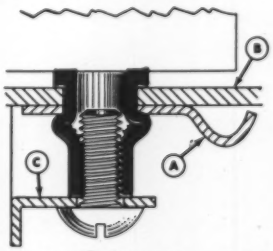
B.F. Goodrich Rivnut

cuts fastening time, saves money by doing two jobs in one operation!

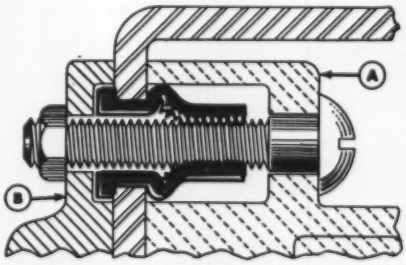
Do you have dual fastening problems like these?



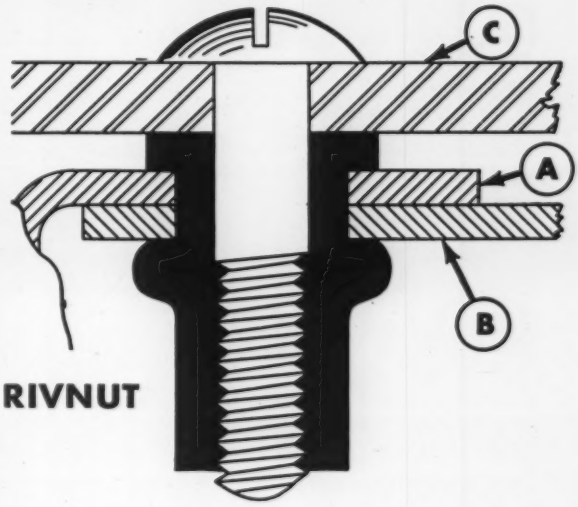
In airplane window seal, Rivnut rivets plate (A) to center post (B), provides nut plate to hold clamp strip (C). Rivnut head serves as spacer for transparent plastic sheets (D). Result: a neat, weather-tight seal!



In vaporizer assembly, Rivnut rivets upper flange (A) to casing (B), makes firm, accurate nut plate for attachment to lower flange (C). Rivnut eliminates reinforcing plate. Result: less assembly time, fewer parts, better product.



Rivnut provides 6-thread nut plate for attachment from either end—or *both*. In spotlight assembly, Rivnut replaces awkward welded stud for attaching socket (A). Plug base (B) is attached on other side. Result: fewer operations, lower assembly cost.



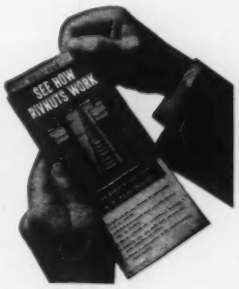
B. F. GOODRICH RIVNUTS cut costs and speed assembly because they rivet two parts together, make a firm, accurate nut plate for a third. And they do both jobs in one quick operation! Rivnuts can be installed from one side, take an attachment bolt from either end. They eliminate welding, tapping, clinching.

In the transformer assembly above, one worker fastens the metal cover (A) to the plastic sheet (B) with Rivnuts in seconds. Rivnuts then serve as mounting lugs for attaching completed transformer to mounting plate (C).

B. F. Goodrich Rivnuts have speeded up thousands of fastening jobs—can do the same for you. Write today to *B. F. Goodrich Company Tire & Equipment Division, Rivnut Sales, Akron, Ohio.*

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten WITH and TO. Explains construction, simplicity of installation. Get your free copy today by writing to: The B. F. Goodrich Company, Dept. MD-8A, Akron, Ohio.



B.F. Goodrich RIVNUTS

The only one-piece blind rivet with threads

Actual size

VERSATILE SYNCHRON TIMING MOTORS* MASTER RUGGED SONAR DUTY

- constantly exposed to salt water atmosphere
- operate without failure under 30% overload

The Synchron Motors used in Ross Laboratories' depth finding equipment are exposed constantly to salt atmosphere under normal operating conditions. High voltage of the primary electrical source causes as much as 30% overload on the Synchron Motors.

In most cases, these factors would be certain "death" for a timing motor. But not Synchron . . . the little masters of big jobs operate the sonar efficiently with a low breakdown rating of less than ½ of one percent.

The engineers at Ross Laboratories, Seattle (Wash.), specify Synchron Motors exclusively to power the ultra-sensitive depth finding equipment the company designs and manufactures for use in commercial fishing boats and pleasure craft. The equipment, sold under the trade names Sportsman and Fisherman Depth Finders, is vital in navigating, anchoring, and fishing.

Synchron Timing Motors are precision engineered and thoroughly tested for durability, accuracy, and dependability. Each motor is made with standards as fine as .0001 tolerance and subjected to 51 individual inspections. The pinion and shaft are machined in one piece from solid steel. Oil-retaining double bearings are provided on the rotor shaft, the reduction train, and the output shaft.

"Workhorse of the industry"

*Synchron synchronous motors operate smoothly, evenly in any position; at temperatures from —40° to +140°F.; start instantly under load; pull up to 20 in. oz. at 1 RPM. Available in 42 speeds from 0.8 RPM to 600 RPM.

SYNCHRON®

SYNCHRONOUS MOTORS, TIMING MACHINES, CLOCK MOVEMENTS, MAGNATORC D.C. MOTORS

HANSEN MFG. CO., INC. Princeton 12, Indiana

FACTORY REPRESENTATIVES: The Fromm Co., 5254 W. Madison St., Chicago, Ill. • R. H. Winslow Assoc., 123 E. 37th St. New York, N.Y. • Electric Motor Engineering, Inc. 8255 Beverly Blvd., Los Angeles 48, Cal. and 3907 Lyon Ave., Oakland, Cal.

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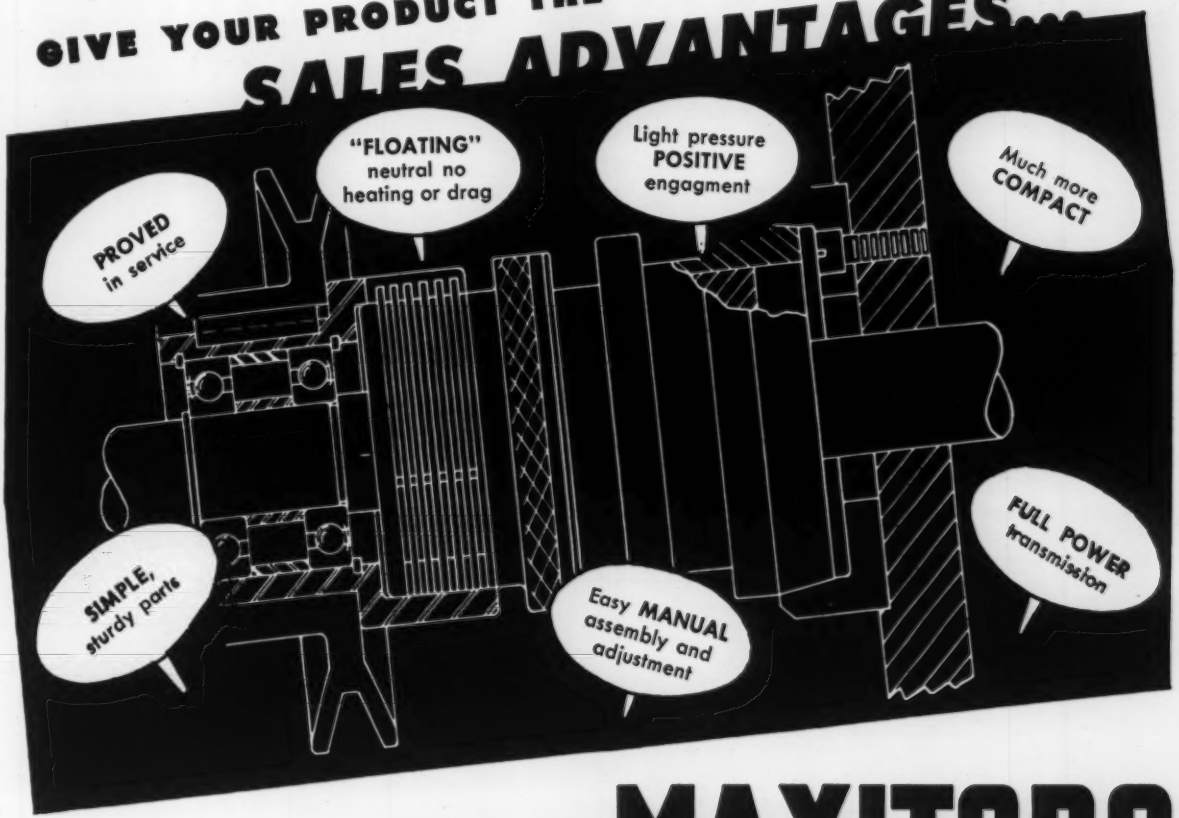
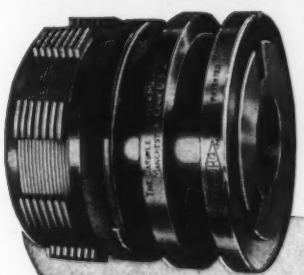
GIVE YOUR PRODUCT THE SALES ADVANTAGES...



...OF A PROVEN MAXITORQ floating disc CLUTCH



The above line drawing illustrates a single MAXITORQ Clutch arranged for single V-belt drive with a special sliding beveled shifter sleeve acting as a light brake.

Yes, there are many types of MAXITORQ . . . single, double, overload release . . . to meet every installation need. Get our comprehensive technical data . . . let our engineering department help you work out special drive problems. Write or phone: Dept. MD-8, The Carlyle Johnson Machine Company, Manchester, Conn.

Let's talk MAXITORQ

5CJ55

—ITEM 540—
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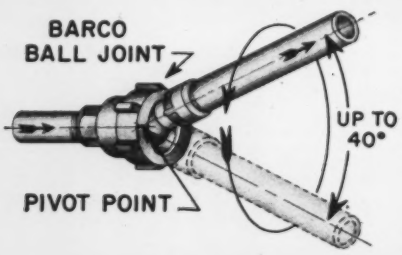
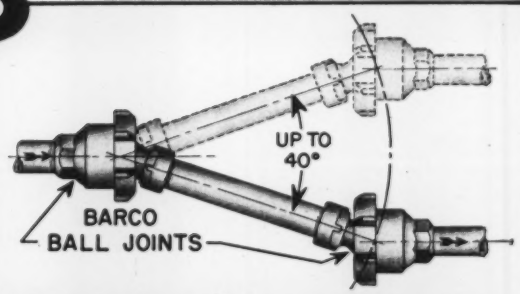
Barco Flexible Ball Joints

for solving piping problems { MOVEMENT • ALIGNMENT • EXPANSION
CONTRACTION • VIBRATION • SHOCK

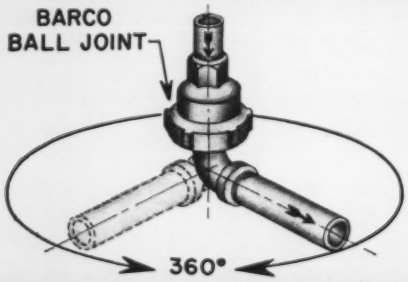
BARCO



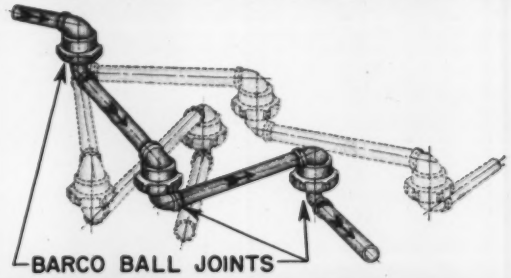
ONE JOINT—Provides for angular motion or positioning of piping in any plane. (Also see below.)



TWO JOINTS—This arrangement provides for piping alignment or simple flexible connection.



ONE JOINT—Allows for full 360 swivel or swing motion, in addition to angular movement shown above.



THREE (OR MORE) JOINTS—For complete flexibility. Any angle! Any radius! Any plane! Many arrangements possible.

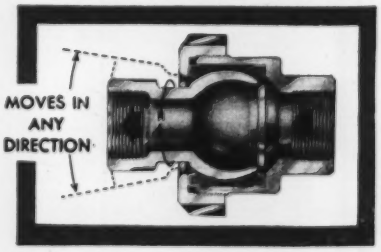
For Use by Design Engineers

THE four basic principles of motion illustrated above make the BARCO Flexible Ball Joint one of the most useful, most versatile fittings ever developed for piping conveying chemicals, oil, steam, water, air, and countless other fluids. *One joint often does the work of two or more ordinary swivel joints, because it moves in any direction!*

Metal pipe made flexible with Barco Flexible Ball Joints is practically indestructible. Long range planning calls for the permanence of this type of construction—*for freedom from maintenance and replacement, and SAFETY!*

There are many applications for Barco Flexible Ball Joints in industry: (1) To permit movement, (2) To accommodate expansion and contraction, (3) To provide for alignment, (4) To insulate against vibration and shock. For piping up to 12″. Wide choice of styles and materials. *Let us give you the complete story.*

GET THE FACTS—New Catalog 2158 is an interesting, illustrated handbook on the application of Barco Flexible Ball Joints. Send for your copy NOW.



BARCO *Manufacturing Co.*

506J Hough Street • Barrington, Illinois

THE ONLY TRULY COMPLETE LINE OF FLEXIBLE BALL, SWIVEL, SWING, AND REVOLVING JOINTS

—ITEM 541—
For More Information Circle Item Number on Yellow Card—page 19

The ring of quality

Colorful, low-cost sidewall rings that can be quickly installed on tires are now contributing to the luxury-look of today's new cars. They're inexpensive, stay brilliant for life, wash bright in seconds, out-last tires. A product of The Bearfoot Sole Co., Wadsworth, Ohio, these rings are available in a variety of colors or in white. They're made of Enjay Butyl Rubber because no other rubber tested could equal its performance in severe laboratory and road tests. The Enjay Butyl label on the Flex-A-Wall® carton assures the buyer of outstanding quality.

Find out for yourself the many technical advantages of Enjay Butyl—the rubber that is outperforming natural and other types of rubber in a wide variety of industrial and consumer applications. For full information, and for technical assistance in the use of Enjay Butyl, write, wire or phone the Enjay Company.

ENJAY BUTYL

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Other offices: Akron • Boston • Chicago • Los Angeles • Tulsa

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

MONSANTO

The speed with which new products pass through the designing stage to final marketing is one of today's industrial phenomena. One factor which has contributed heavily to this is the availability of a wide range of plastic materials with highly usable combinations of properties. And, collaterally, there are the custom molders whose working knowledge and craftsmanship in plastics translate the manufacturer's designs and plans into highly serviceable, highly attractive finished articles. Read how one of America's leading appliance manufacturers collaborated with the custom molder to produce the part that "makes" his new appliance.

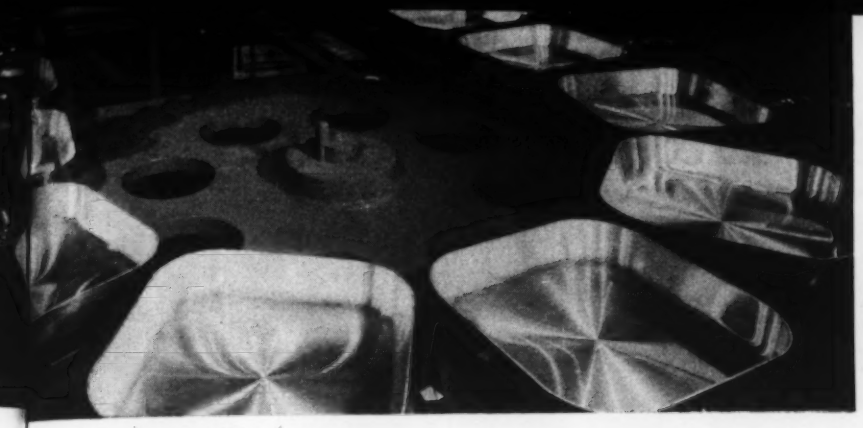
New handle of Resinox phenolic plastic houses "the brain" of the new Sunbeam Fry-Pan

DESIGN OBJECTIVES To design the handle for the Sunbeam Fry-Pan, an aluminum frying pan, electrically wired to "do its own cooking." To its designers, Sunbeam Corporation of Chicago stressed two things: functional beauty and long service life. Cost, of course, as on all high-volume competitive products, was also a consideration.

MATERIAL SPECIFICATION In the Fry-Pan, the handle is the "brain"—housing the temperature setting controls, signal light, and automatic regulators that govern the 1150 and 1450 watt tubular element sealed in the base of the pan. Specifications dictated that this handle be inserted into the apertures of the thermostat, then sealed in 3 seconds by a Hannifin hydraulic press. Over 30 exhaustive tests were made to screen different materials in the conditions to which the handle would be subjected in use. Surface finish and hardness, resistance to detergents and boiling water, weight, dielectric strength, and durability were all major factors in determining the material. Monsanto Resinox phenolic plastic was selected. A handle molded of this phenolic had a high natural surface gloss, heat-resistance, and inherent color. It could be repeatedly immersed in boiling water with no ill effects . . . was tough and long lasting.

Chief Mold Designer for Prolon Plastics Co., Mr. Clyde Morrell.

PRODUCTION Prolon Plastics Company, Florence, Massachusetts, a division of Pro-phy-lac-tic Brush Company, was awarded the job of producing the Fry-Pan handles. In addition to an enviable reputation for high quality molding, Prolon had also demonstrated a productive capacity to meet Sunbeam's production rate. For this handle assignment, Prolon engineers decided on Monsanto Resinox 5797. A free-flowing phenolic molding compound, Resinox 5797 has rapid cure and rigid set, two reasons for its wide use for wiring device parts. It produces parts with a very smooth,



hard surface. Equally important, Resinox 5797 meets the critical heat requirements on the Fry-Pan where heat is constantly re-applied to this molded handle. Using Resinox 5797, Prolon molded a handle with a life expectancy far exceeding the required 2000 hours. In fact, if the housewife uses her Sunbeam Fry-Pan with its Resinox handle for 7 hours a week, 52 weeks of the year, she can expect over 5½ years of service under such severe usage.

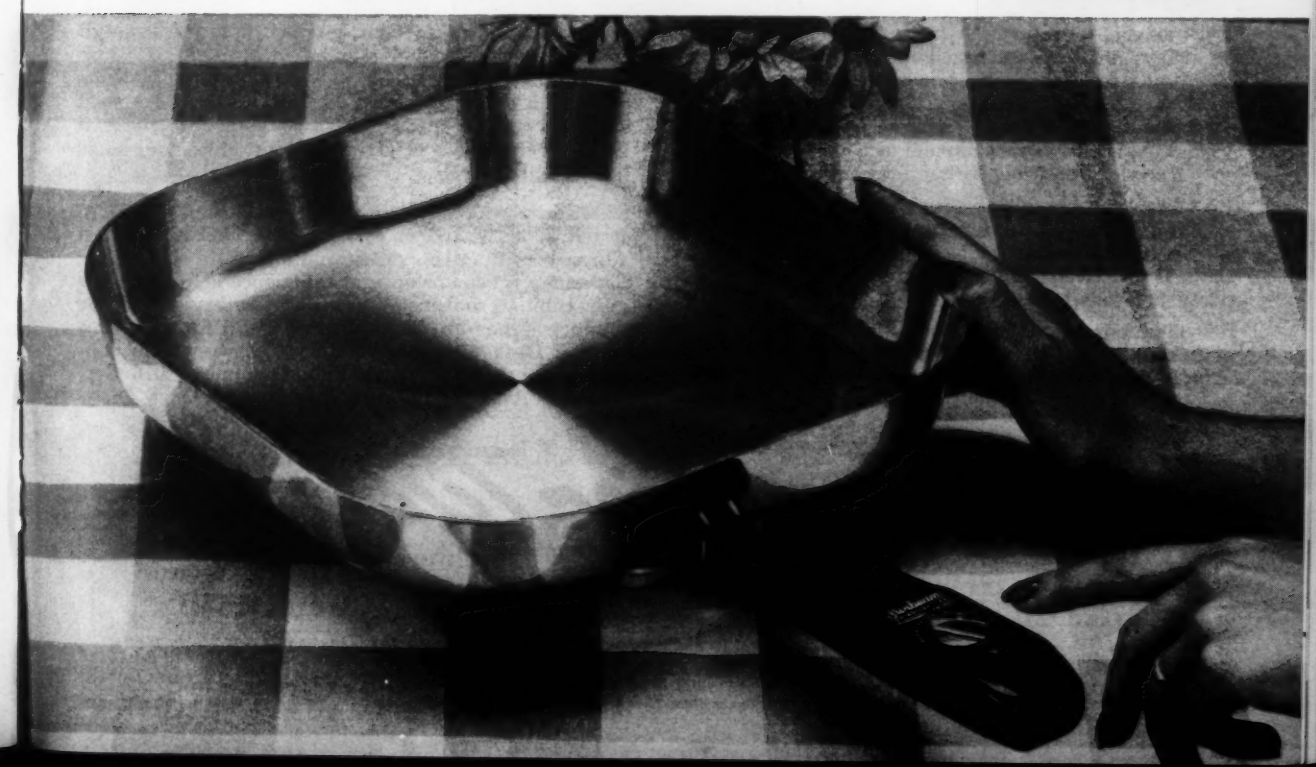
THE FINISHED PRODUCT The popularity of the Sunbeam automatic Fry-Pan is a tribute to the usefulness of this work-saving kitchen appliance. Practical usefulness has been achieved by following the precepts of functional design and simplicity of form. The jet black lustrous handle of Resinox phenolic plastic adds a high note of functional beauty.

Here is one of the hundreds of design and production problems solved by utilizing the facilities of the plastics custom molding industry. If you are considering a design change or new product, investigate plastics, and the design, engineering, and molding facilities available to you through plastics molders, the Craftsmen of the 20th Century. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who will put their skills to work for you. Write to Monsanto Chemical Co., Industrial Applications Dept., Springfield 2, Mass.

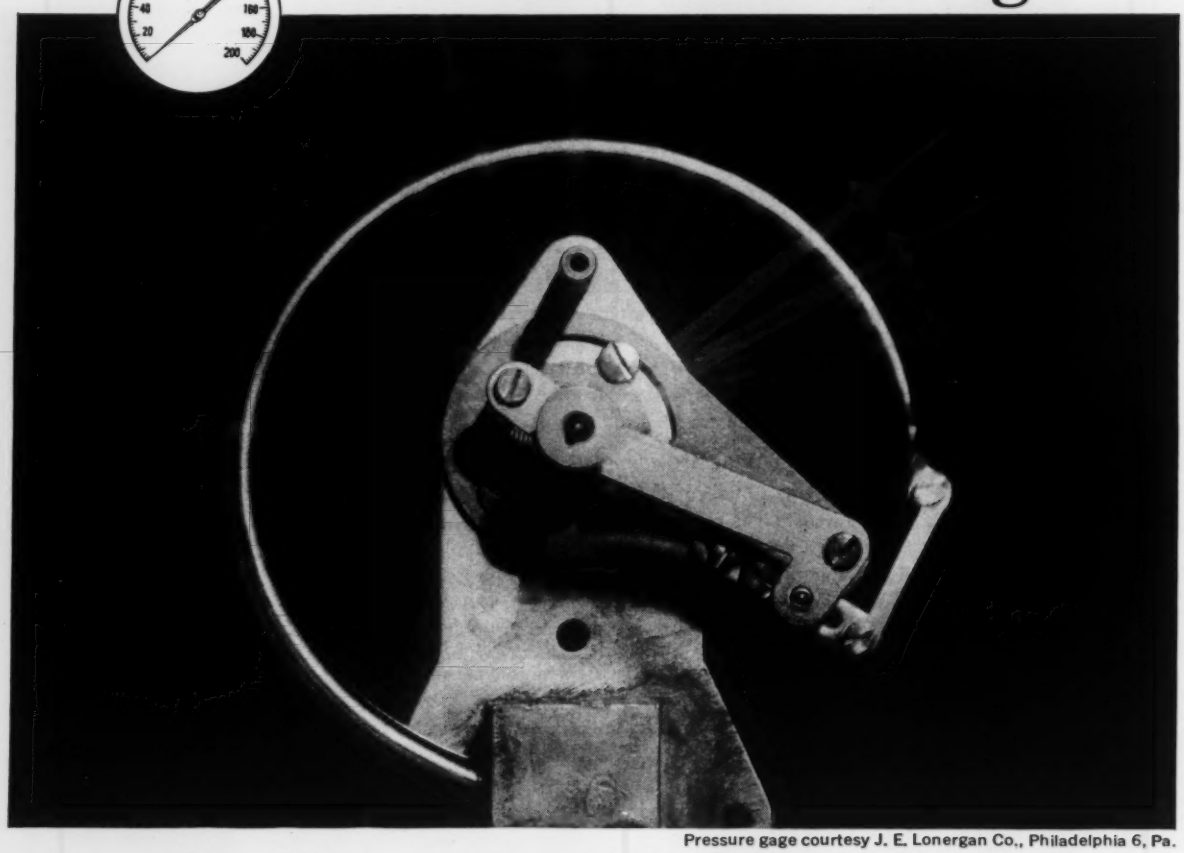
Investigate Monsanto's complete line of phenolic plastic compounds developed for particular applications and sold under the trade name...

RESINOX®

MONSANTO



Non-Habit-Forming



Pressure gage courtesy J. E. Lonergan Co., Philadelphia 6, Pa.

Beryllium Copper Tubing by Superior

This unusual term describes perfectly one of the most important properties of beryllium copper tubing. The Bourdon tube shown above is an excellent example. Once the beryllium copper tube is in the gage, it "remembers" its job and acquires no new habits. It yields constantly to pressure and as constantly returns to its original position without taking a new "set."

Beryllium copper tubing by Superior has this and many other important characteristics to a marked degree, such as hardenability, corrosion and fatigue resistance, thermal and electrical conductivity. It is easy to fabricate, it is nonmagnetic.

Beryllium copper tubing lends itself to a wide variety of applications. It can be severely worked to form convoluted flexible waveguides and bellows. Cold drawn to specifications, followed by proper hardening, it makes an excellent aircraft antenna, with the strength to withstand thousands of hours' vibrating in 100 mph winds. Used as a contact roll in a business machine collator, it is wear and corrosion-resistant, and a good electrical conductor. Or, as above, shaped for use as a Bourdon tube, it is tough, ductile, durable—and holds its original shape.

Superior produces tubing in over 63 analyses . . . in stainless, alloy and carbon steels, nickel and nickel alloys, beryllium copper, titanium and zirconium. Let Superior's tubemanship and experience help you solve your tubing problems. You'll like the service and the products—they *are* habit-forming. Send for your free copy of Data Memorandum No. 7 on beryllium copper tubing. Write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

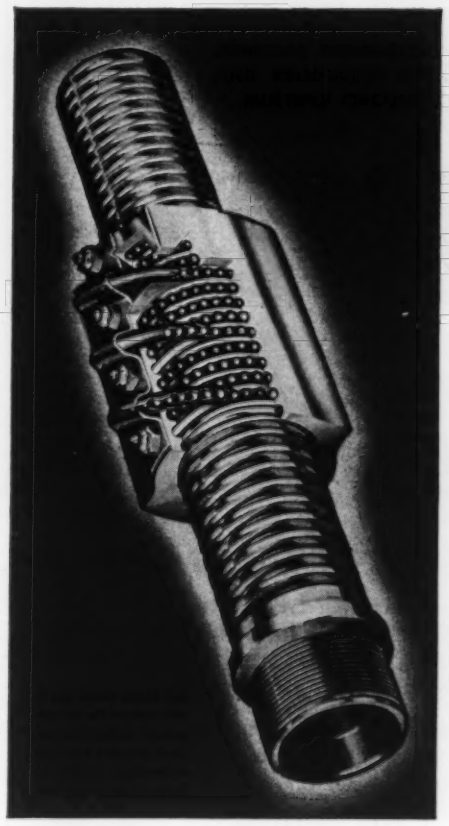
West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

—ITEM 544—

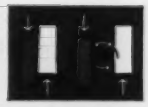
For More Information Circle Item Number on Yellow Card—page 19

SAGINAW b/b SCREWS are guaranteed 90% EFFICIENT!

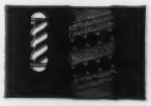
Require 2/3 LESS torque than Acme Screws for same linear output on Actuator and Positioner Applications! Saves space, weight!



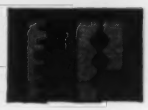
WHAT IT IS AND HOW IT WORKS



Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



the *Saginaw ball/bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.

At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

DESIGN ADVANTAGES

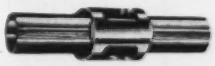
1. Increases efficiency — Acme screw is 15%-20% efficient — b/b screws are 90%-95% efficient.

2. Saves power — requires 2/3 less torque than Acme screws for same linear output.

3. Saves space — permits smaller motors, gear boxes; eliminates pumps, piping, accumulators.

4. Assures positive positioning — permits precision control within thousandths of an inch.

SAGINAW b/b SPLINE



Utilizing the same basic *gliding ball* principle, Saginaw has developed the *Saginaw b/b Spline* which radically increases the efficiency of transmitting or restraining high torque loads.

Averages 40 times lower friction coefficient than sliding splines!

It can be fitted with integral gears, clutch dogs, bearing and sprocket seats, etc., for use with a wide variety of electrical units. AVAILABLE IN ALMOST ANY SIZE. (Units have been engineered as small as 3/8 IN. IN DIAMETER.)

Saginaw ball bearing Screws & Splines

SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

SEND COUPON FOR 32-PAGE ENGINEERING DATA BOOK

Saginaw Steering Gear Division, General Motors Corporation
b/b Screw and Spline Operation
Dept. 9H, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME_____

COMPANY_____ TITLE_____

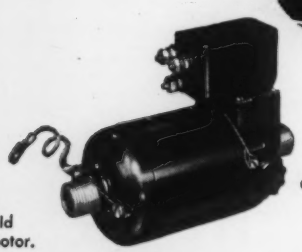
ADDRESS_____

CITY_____ ZONE_____ STATE_____

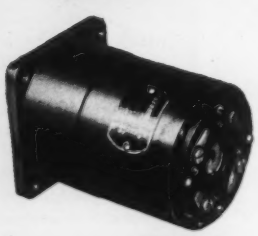
—ITEM 545—

For More Information Circle Item Number on Yellow Card—page 19

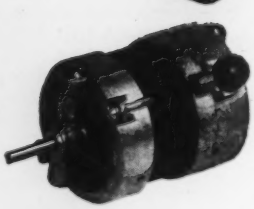
Explosion-proof vacuum unit.



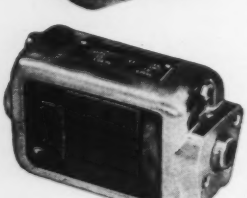
Aircraft windshield wiper motor.



Radar voltage regulator gear motor.



Weight-saving home appliance motor.



For motor-driven office equipment.

If you are interested in any of the above motors write and we shall be glad to send full information.

Thoroughbred *Fractional* HORSEPOWER

for your motor-driven products

The unexcelled performance of Lamb Electric Motors in many types of industrial, commercial and domestic products is evidence of their outstanding quality.

Dependability and efficiency (optimum weight-size-horsepower ratio) are features that result from proper design and careful manufacture by personnel having many years of experience in the small motor field.

May we demonstrate how Lamb Electric Motors can bring these advantages — and also perhaps lower costs — to your products?

THE LAMB ELECTRIC COMPANY • KENT, OHIO

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 29

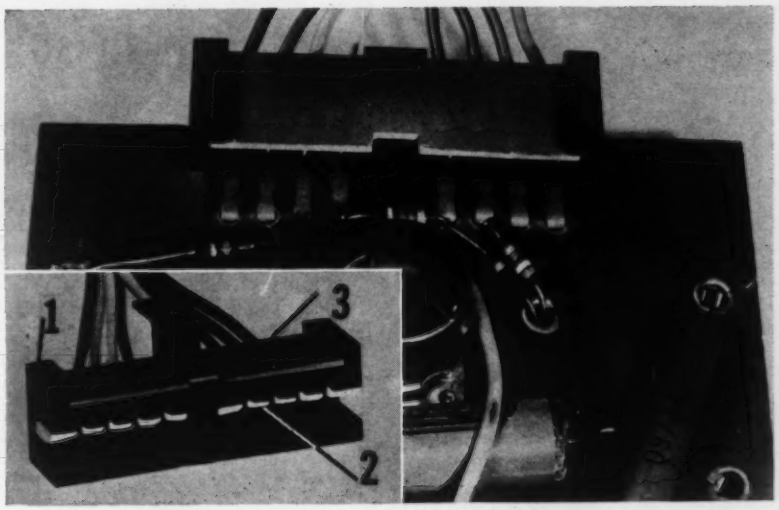
New Silicone Bonded Mica Tape More Flexible, Easier to Handle

Mica Coated Products Co., Salem, Mass., has developed an improved Class H insulating material comprised of a thin coating of ground mica bonded to glass cloth with Dow Corning 994 Varnish.

According to the manufacturer, this new combination provides greater dielectric strength and heat resistance than possible with silicone-glass alone. In addition, it has far greater flexibility than conventional tapes made with mica-splittings. A 5-mil thickness of it may be wrapped around a 1/32" mandrel without harm.

This new material is unusually uniform in gage, finish and dielectric strength. Since it is neither tacky nor slippery, there is no danger of its welding together or blocking when guillotine-cut.

The flexibility of Dow Corning 994 Varnish and its compatibility with mica led to its use as the binder for ground mica coating on two other new tapes by Mica Coated Products Co.: an alkyd resin dipped glass cloth for temperatures up to 170 C; and Mylar, for Class B applications. The silicone-mica combination gives both tapes appreciably greater resistance to fire and arcing. *No. 290*



(1) Phenolic wire holder (2) Silastic strip (3) Micarta cover.

WESTINGHOUSE USES SILASTIC IN NEW LOW COST CONNECTIONS

Right along with the new and frequently more complex designs that give products greater consumer appeal, there is also a continuing need for other new designs that help reduce assembly costs and keep the product in a competitive position costwise. Just such a design idea has taken form in the push-on connectors which join circuit sub-assemblies on the Westinghouse Automatic Corox range.

The ultimate in design simplicity, these push-on connectors force the lead wires to make their own connections without clips, clamps, screws or solder. The connectors consist of only three parts: (1) a molded phenolic wire holder; (2) a compression strip of Silastic,* Dow Corning's silicone rubber; (3) a plain Micarta cover which slips over the exposed wires to permit safe handling.

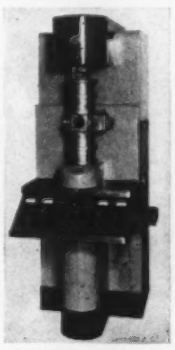
The stripped wires are inserted into their proper numbered V-notches in the holder and are simply bent over the compression strip of Silastic. The Silastic provides a resilient rubber "spring" which presses the wires into tight contact with the terminals on the amplifier mounting board. Silastic is specified by Westinghouse designers because of its superior dielectric strength and permanent resistance to compression

*T. M. REG. U. S. PAT. OFF.

(cont'd pg.2)

Assure Efficiency of Electronic Microscope With Silicone Pump Fluids

Stymied by the limitations of organic diffusion pump oils, many designers now improve product performance by specifying Dow Corning silicone fluids for vacuum pumps. Take the RCA electron microscopes and diffraction cameras, for example.



A vacuum in the range of 10^{-4}mm. of mercury must be maintained in these instruments to permit an electron to leave the filament and travel the entire length of the chamber without hitting an air molecule.

Each time an instrument is opened, however, the chamber must be completely evacuated or "pumped-down" before it can be used again. Pumping down used to be the most time-consuming part of operating these instruments, but now, through improved design, RCA has reduced pump-down time to less than two minutes.

During normal operation of RCA's Model EMT, large amounts of raw air frequently enter the diffusion pump while it is hot. Exposed to such conditions, organic diffusion pump oils rapidly carbonize and break down. To assure excellent service right from the start, RCA furnishes a bottle of Dow Corning 702 Fluid with each new microscope or camera.

A recent check indicates that even after two years of continuous use in these instruments, the Dow Corning silicone fluid remains in excellent condition.

(cont'd pg.2)

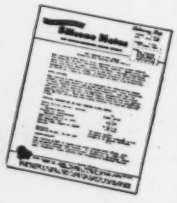
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

Silicone News

DOW CORNING CORPORATION

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



Silicone-based protective coatings are durable protective finishes for appliances; long-lasting maintenance paints for equipment exposed to adverse conditions. A recently published brochure includes typical applications and a list of companies formulating silicone paints. *No. 295*

1956 Reference Guide to Dow Corning Silicone Products. A concise, comprehensive, 12-page reference that is convenient-to-use. It's packed with data, properties, and information on how you can use silicones in designing new equipment, improving performance and reliability of original equipment, or reducing production and maintenance costs. *No. 296*

"Effects of High Temperature on the Properties of Organic and Silicone Rubbers," a recent article from RUBBER AGE, reviews the marked immediate effects of heat aging on physical properties of rubbery materials. Includes 20 graphs which enable design engineers to select the most suitable type of rubber for applications where retention of properties is critical. *No. 297*

"151 Uses for Silicones in Metalworking." A reprint from STEEL, condenses and lists known applications for silicones in Design, Production, Maintenance and Miscellaneous categories. Provides a quick reference as to how Dow Corning Silicones help solve problems in many segments of the metalworking industry. *No. 298*

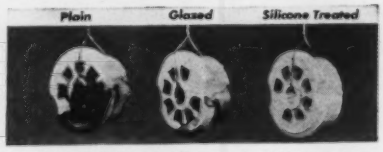
Silicone-Glass Laminates for electrical and mechanical applications are described in new brochure which illustrates parts used in typical industrial applications. Also provides engineering information on silicone-glass laminates and lists fabricators of such laminates. *No. 299*

New engineering brochure featuring Silastic 50 and Silastic 80 is now available. A convenient reference, it includes detailed information on the physical and electrical properties of these two practical, general purpose silicone rubbers. *No. 300*

Silicone Coating Cuts Cost of Ceramic Electrical Insulators

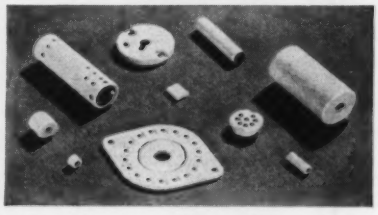
Imaginative use of new materials frequently enables designers to create a competitive sales advantage while cutting production costs. Here's a case in point from Centralab Division of Globe-Union Co., Milwaukee.

Centralab reports that a silicone treatment is rapidly replacing conventional glaze coatings on ceramic electrical insulators. Production savings with the silicone treatment range as high as several dollars per thousand units, permitting Centralab to quote competitively for ceramic against ordinary plastic molding materials.



Greater moisture repellency of silicone treated ceramic tube socket is demonstrated by dunk test using colored water.

The new treatment consists simply of a dip in Dow Corning 200 Fluid followed by a short baking cycle, contrasted to the costly individual air-brushing and high temperature kiln-firing required for a glazed surface. The silicone treatment gives equivalent or better moisture resistance and surface resistivity for all but the highest frequency applications.



Centralab now offers the silicone treatment on its entire line of steatite-ceramic parts including insulators, capacitor bodies, rotary switches and trimmers. Silicones have become such a strong selling point that, as a Centralab spokesman puts it, "Our sales department reviews every order or quotation request calling for glaze and recommends the silicone treatment where ever possible." *No. 293*

DIFFUSION PUMP *(continued)*

Tests by other leading producers of high vacuum equipment indicate that Dow Corning 702 Diffusion Pump Fluid helps to attain higher vacua in less time than possible with organic fluids. *No. 292*

WESTINGHOUSE *(continued)*

set. With the addition of screw-on brackets, these ingenious push-on connectors also serve to fasten the entire amplifier circuit to the range body, thus providing an additional saving in assembly time.

Today, designers are finding an ever increasing number of new uses for Silastic where product performance can be improved with a rubbery material that retains its physical and dielectric properties far beyond the limits of organic rubber. *No. 291*

SILASTIC PROTECTS BEARING ON MAYTAG CLOTHES DRYER

Over a broad temperature span, from —130 to 500 F, Silastic, Dow Corning's silicone rubber, keeps its shape and stays resilient. Here's how Maytag designers have translated this unique thermal stability into practical use in their automatic clothes dryers.

Backbone of the Maytag dryer is a sintered metal journal bearing which supports the drum shaft. This bearing is protected from moisture by a Silastic seal on the shaft. The seal, molded by Maytag, has been in use since the dryer was introduced three years ago.

Despite repeated exposure to steam and ambient temperatures ranging up to 170 F, the Silastic seal has demonstrated its ability to remain resilient and watertight for the full service life of the unit. *No. 294*

Dow Corning Corporation, Dept. 6808, Midland, Michigan

Please send me: 290 291 292 293 294 295 296 297 298 299 300

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE____ STATE_____

SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION

first in silicones

DOW CORNING SILICONES

MIDLAND MICHIGAN

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CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

Jenkins designed for trouble-free performance... a

STAINLESS STEEL "Y"

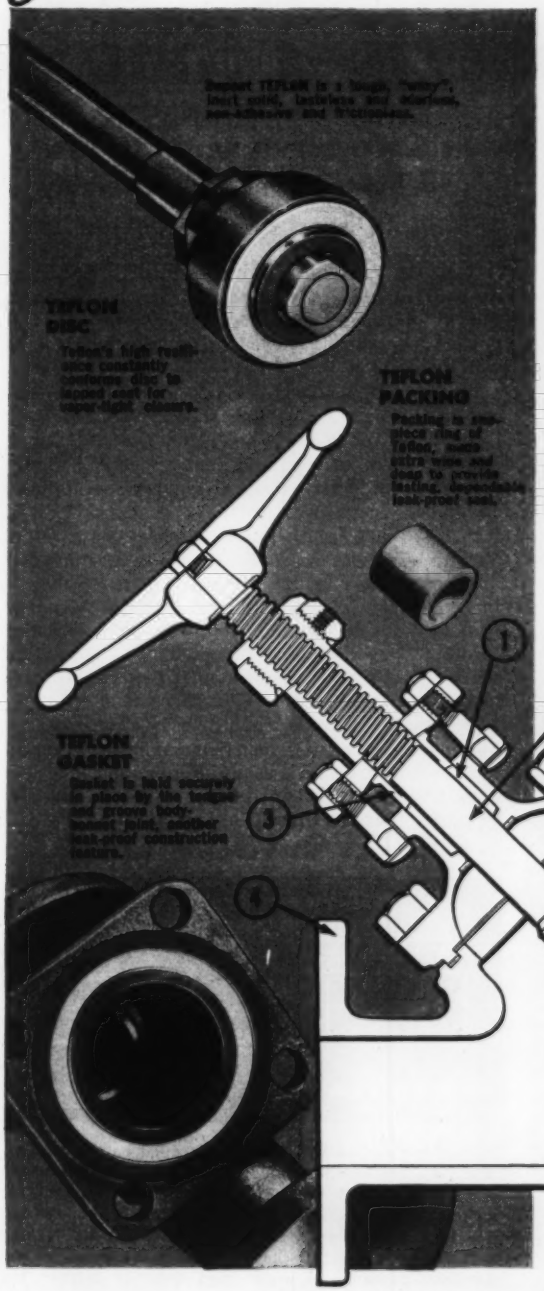
to lower costs in a wider range of

CORROSIVE SERVICES

For food and chemcial plants, and similar services, Jenkins Fig. 1335 "Y" Globe offers many advanced features that will lower operating costs and keep your processing lines trouble-free. The disc, packing, and gasket are tough, resilient Teflon. Tasteless and odorless, it eliminates problems of contamination.

The "Y" pattern permits full flow, nearly equal to that of a gate valve, and also provides the vapor-tight closure and the ease of disc renewal of a globe valve.

Fig. 1335 offers extra value by any test . . . *initial cost, operating efficiency, low maintenance.* You can convert this extra value into *extra savings* on your toughest corrosive services. Call your Jenkins Distributor, or write: Jenkins Bros., 100 Park Ave., New York 17.



FULL, FREE FLOW through Fig. 1335 is nearly equal to flow through a gate valve.

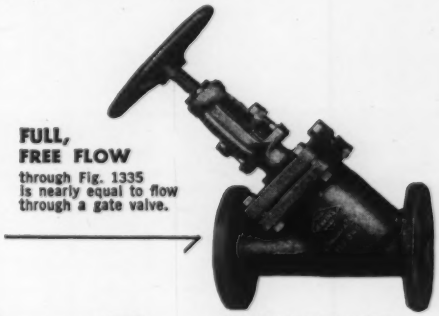


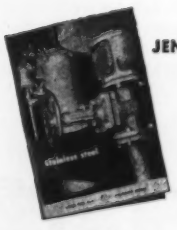
Fig. 1335 "Y" GLOBE
150 lbs. O.W.G. at 500°F
230 lbs. O.W.G. at 100°F
Sizes 1" to 4"

(1) **Packing Box**—Exceptionally deep and wide to hold optimum size packing.

(2) **Spindle**—Polished shank, long-operating threads, bevel shoulder for backseating.

(3) **Gland**—Two-piece for equalized pressure, tight seal.

(4) **Flanges**—Conform to M.S.S. Standard Practice S.P.42 Specifications.



JENKINS STAINLESS STEEL VALVE BOOKLET illustrates and describes wide range of Jenkins Globe, Gate, Check, and Y Valves, includes selection data, survey forms. Ask for Form 200-A.

—ITEM 548—
For More Information Circle Item Number on Yellow Card—page 19

Flexloc thin nuts save space, weight and production time

Self-locking nuts are 30% lower and lighter; speed up assembly with hand or power tools

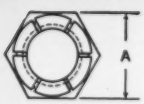
Self-locking FLEXLOC thin nuts are 30% lower than regular height locknuts of the same nominal diameter. They fit into spaces where regular height locknuts will not go. You can design lighter, more compact units with them.

Where you must reduce weight in a completed assembly, you can save by using shorter bolts with these lighter nuts. And you save production time. The length of engagement of mating threads is shorter: fewer revolutions of hand wrenches or power nut runners are needed to seat them.

FLEXLOC nuts are of 1-piece, all-metal construction. You can use a FLEXLOC fully seated as a locknut or at any point along a bolt as a stop nut. Once the threads in the resilient locking section are fully engaged, the FLEXLOC grips the mating threads with uniform locking torque wherever wrenching stops. Since there are no nonmetallic inserts to come out or deteriorate, the locking life of a FLEXLOC is virtually unlimited.

Your authorized industrial distributor stocks FLEXLOC nuts in a variety of sizes, materials and finishes. Consult him for details. Or write us for information about your special locknut problem. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

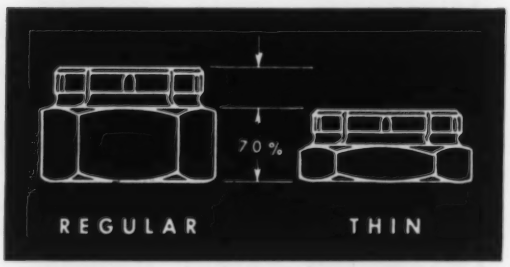
SPECIFICATIONS
FLEXLOC THIN NUTS



NATIONAL COARSE THREAD—U.S.S

SIZE	A INCHES	H INCHES	WIDTH ACROSS CORNERS	WEIGHT PER 1000 NUTS
6-32	.312	.125	.361	1.8
8-32	.344	.172	.397	2.8
10-24	.375	.172	.433	3.3
¼-20	.438	.203	.505	5.4
5/16-18	.563	.250	.649	11.6
⅜-16	.625	.265	.722	14.9
7/16-14	.750	.312	.866	24.9
½-13	.813	.312	.938	28.4
9/16-12	.875	.359	1.010	36.1
⅝-11	1.000	.391	1.155	54.1
¾-10	1.125	.406	1.299	69.2
⅞-9	1.312	.469	1.516	107.5
1-8	1.500	.563	1.732	171.6
NATIONAL FINE THREAD—S.A.E.				
6-40	.312	.125	.361	1.8
8-36	.344	.172	.397	2.8
10-32	.375	.172	.433	3.3
¼-28	.438	.203	.505	5.4
5/16-24	.500	.250	.577	8.7
⅜-24	.563	.266	.649	11.5
7/16-20	.625	.312	.722	14.9
½-20	.750	.312	.866	21.7
9/16-18	.875	.359	1.010	36.2
⅝-18	.938	.391	1.082	42.4
¾-16	1.063	.406	1.227	54.5
⅞-14	1.250	.469	1.443	84.6
1-14	1.438	.563	1.660	136.3
1 1/16-12*	1.625	.625	1.876	193.5
1 1/4-12*	1.813	.750	2.093	296.0
1 3/8-12*	2.000	.812	2.309	389.0
1 1/2-12*	2.187	.875	2.526	498.0

*Steel only (plain or cadmium plated) in stock sizes.



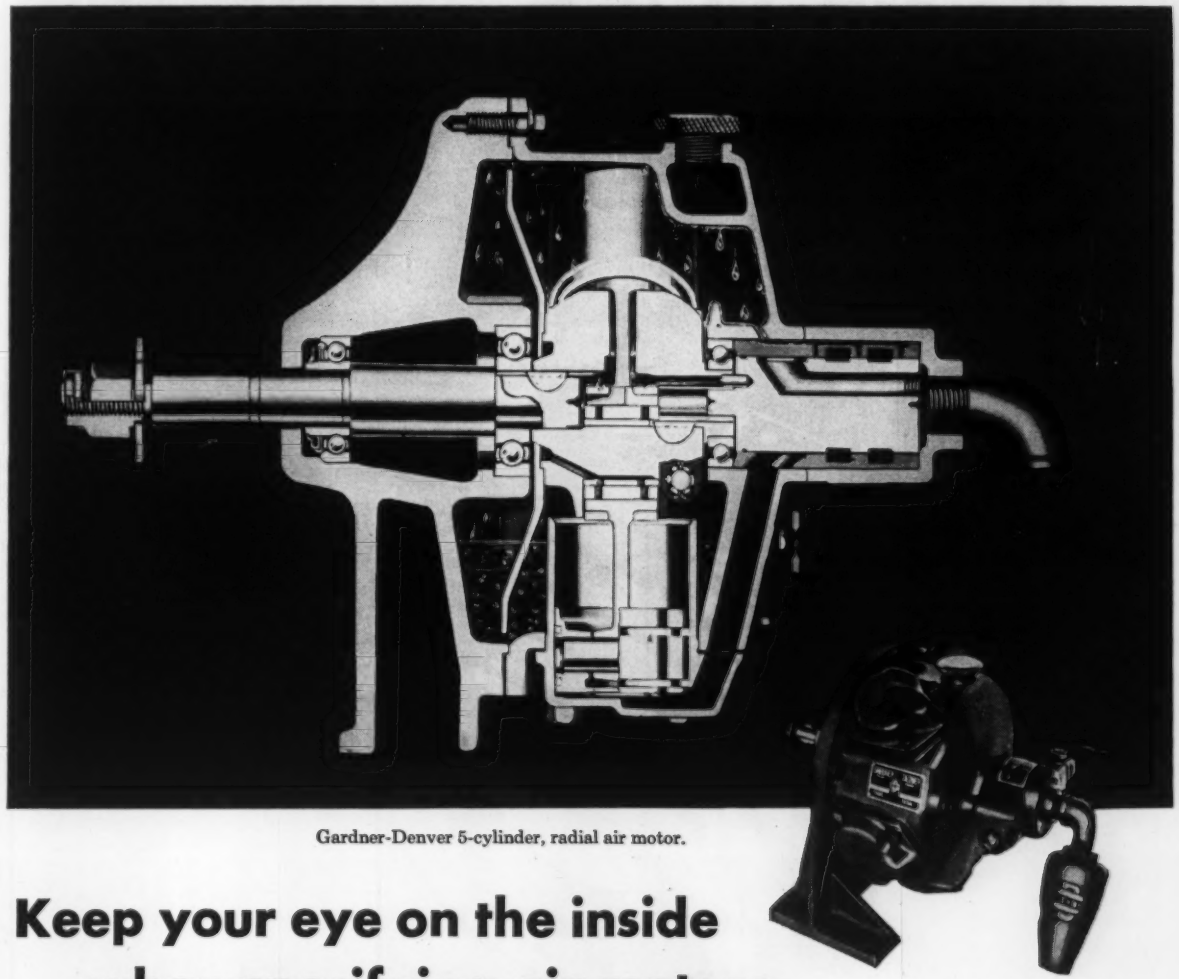
FLEXLOC thin nuts are 30% lower than regular height locknuts. There is a corresponding saving in weight. In sizes through 5/16 in., thin FLEXLOCs meet tensile strength requirements for regular height locknuts. FLEXLOC nuts can be made in the thin type because every thread, even those in the locking section, carries its full share of the load. There are no nonmetallic inserts to waste head space or weaken the structure of the nut.

Standard FLEXLOC self-locking thin nuts are available in plain or cadmium plated alloy steel, for use in temperatures to 550°F; in plain or silver plated corrosion resisting steel, for temperatures to 750°F; and in brass and aluminum, for temperatures to 250°F.

STANDARD PRESSED STEEL CO.
FLEXLOC LOCKNUT DIVISION SPS
JENKINTOWN PENNSYLVANIA

—ITEM 549—
For More Information Circle Item Number on Yellow Card—page 19

Gardner-Denver . . . Serving the World's Basic Industries



Gardner-Denver 5-cylinder, radial air motor.

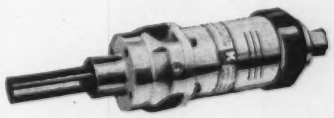
Keep your eye on the inside . . .when specifying air motors

Here's one product you can specify and forget when it comes to compressed air powering. Precision workmanship applied to top-quality materials is the reason. Gardner-Denver multi-use air motors excel in safety, control flexibility, high torque and freedom from overload damage.

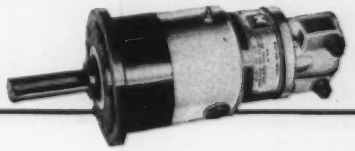
5 sizes; 3 to 16 h.p. . . . direct drive or built-in gear reduction . . . reversible or non-reversible—a choice of power and speed for many applications.

JUST A FEW JOBS WHERE GARDNER-DENVER AIR MOTORS PUT IN A FULL DAY'S WORK: Bit Grinders • Bending Rolls • Grout Mixers • Concrete Mixers • Blowers • Pumps • Hoists • Conveyors • Saw Mill Machinery • Engine Starting.

Keller Tool 1 h.p. Rotary Vane Air Motor.



Keller Tool 70A Axial Piston Air Motor.



We'll gladly send specifications.

GARDNER - DENVER

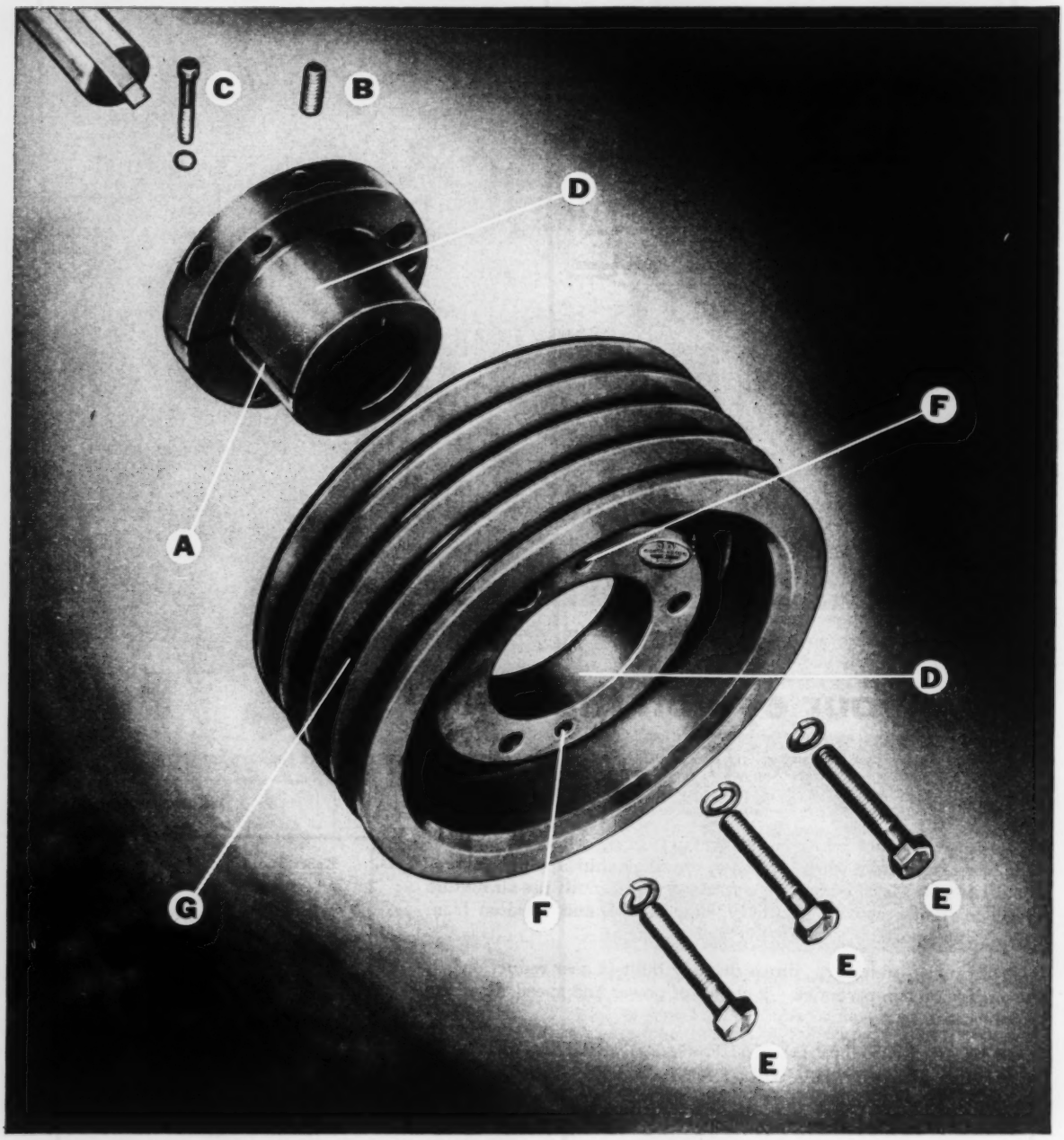
THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

—ITEM 550—

For More Information Circle Item Number on Yellow Card—page 19

Again in '55, industry's



Exclusive design. All Worthington QD sheaves have these outstanding product features:

A- Completely split QD hub holds shaft tightly under heaviest shock loads.

B- Cup point set screw* in QD hub keeps shaft key in position.

C- Clamp screw* secures hub in proper alignment on shaft when mounting sheave.

D- Tapered fit between hub and sheave allows easy-on, easy-off, hold-tight action.

E- Pull-up bolts draw sheave on to hub to produce positive fit on shaft.

F- Tapped holes in sheave permit pull-up bolts to be used as jack screws to break cone grip when removing sheave.

G- Groove cross-sections are accurate and uniform so that each V-belt seats properly, pulls evenly.

**All Worthington-manufactured QD heavy duty hubs incorporate these exclusive features*

best selling sheave

9 outstanding features make Worthington QD the favorite of design engineers

According to authoritative industry figures, more QD sheaves were sold last year than any other type. Design engineers tell us they prefer the QD—the original two-piece design—because of these 9 outstanding features:

1 EXCLUSIVE DESIGN. As shown at left, Worthington QD sheaves have many outstanding product features which mean real benefits to all users.

2 EASY TO INSTALL AND REMOVE, the QD's tapered hub slides on shaft, locks with a cap screw for permanent alignment. Sheave slides on hub and pulls up with three big bolts for tight holding. Comes off just as easily.

3 BALANCED PERFORMANCE of Worthington Multi-V-Drives, due to accurate uniform grooves and precise mating (with Worthington-Goodyear V-belts), gives you even tension, even pull, even speed, even wear, less vibration.

4 SMART APPEARANCE. The QD sheave's scientific design not only provides more efficient transmission of power but actually adds to the looks of your product.

5 QUICK DEPENDABLE SERVICE—factory-warehouses back distributors.

6 MATCHES YOUR QUALITY STANDARDS. QD sheave quality stems from extremely accurate balance, tough close-grained semi-steel metal, rigid inspection for minimum tolerances, and "I-beam" arm construction of driven sheaves which gives greater strength with less weight.

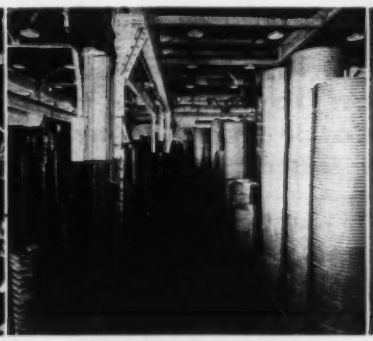
7 WIDE RANGE OF SIZES with factory-warehouse stocks covering over 100,000 V-belt drive combinations from ½ to 600 hp.

8 WIDE RANGE OF APPLICATIONS. QD sheaves have been job-tested and accepted on every class of equipment and in every industry. Some of the many applications in which QD sheaves have given outstanding performances include: blowers, boring mills, compressors, conveyors, crushers, elevators, grinders, lathes, stokers, oil field machinery and many, many others.

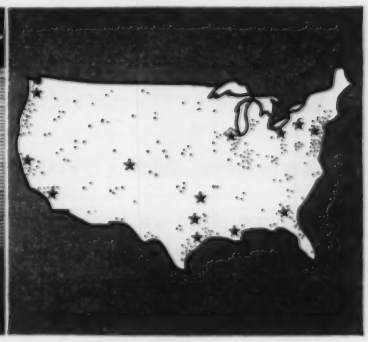
9 COMPLETE ENGINEERING DATA—yours for the asking. In Worthington's 100-page manual, tabbed, easy-to-find tables enable you to select the right sheave and V-belt combination for any job in only three minutes. For your free copy write to Section MV66, Worthington Corporation, Oil City, Pa. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont.

MV.6.6

Over 400 stock Worthington-Goodyear V-belt sizes.



Over 100,000 drive combinations available from warehouse stocks.



13 factory-warehouses back more than 250 distributors.

WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Compressors • Pumps • Multi-V-Drives • Variable Speed Drives

—ITEM 551—

For More Information Circle Item Number on Yellow Card—page 19

It's Here...

A Single Built-in KLIXON Protector Gives Full Protection Engineered into

3-Phase Motors

Specify

and use motors with Built-in

KLIXON PROTECTORS

★ Eliminate Motor Burnouts
★ Reduce Production Down Time ★ Simplify Motor Controls
★ Minimize Motor Repairs and Replacements
★ Assure Maximum Motor Capacity Under Any Conditions

Over-temperature protection is vital to dependable 3-phase motor performance. Now complete protection for 3-phase motors can be yours with a single built-in Klixon Protector.

Now you can get the same dependable protection in 3-phase motors that manufacturers have for years built into single phase motors. This inherent protection is now available to manufacturers of 3-phase motors covering a horsepower range from fractional up through 7½ hp. (600V.)

KLIXON Protectors Prevent Overheating Caused By:
1. Prolonged overloads
2. Single phasing
3. Stalling
4. Failure to start
5. Lack of ventilation
6. Increase in ambient temperatures
7. Plugging or reversing duty

Specify and use motors with Klixon Inherent Protectors. Write for Bulletin MOPR1 for details of inherent motor protection.

KLIXON®

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
3208 FOREST STREET, ATTLEBORO, MASS.

—ITEM 552—
For More Information Circle Item Number on Yellow Card—page 19

over 8000 Different Cylinder SELECTIONS—

Miller

AIR AND HYDRAULIC

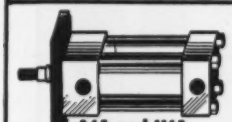
CYLINDERS AND BOOSTERS

"IN STOCK"

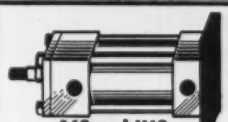
See Miller Bulletins A-105K(Air) and H-104K(Hydraulic) for Complete Dimensions and Engineering Data on these "in-stock" sizes and other Custom Miller Cylinders in bores up to 20" and strokes up to 22 feet.

"IN-STOCK" MODELS

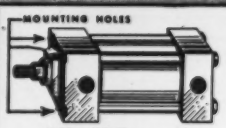
"A" Signifies Miller 200 psi Air Cylinders; "H", 3000 psi Hydraulic Cylinders. Interchangeable Mountings Are Shown In Red On Drawings.



A61 and H61
Flange Mounting on Rod End
(A61 not available in 8" bore)

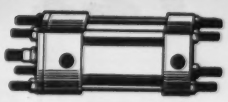


A62 and H62
Flange Mounting on Cap End
(A62 not available in 8" bore)

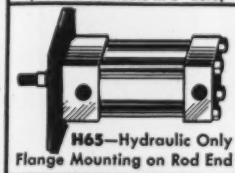


A63—8" Bore only
Flange Mounting on Rod End

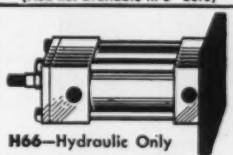
A64—8" Bore only
Flange Mounting on Cap End



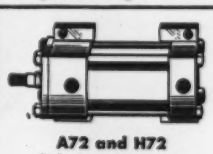
A50 & H50—Tie Rods not extended beyond nuts.
A51 & H51—Tie Rods extended both ends (shown).
A52 & H52—Tie Rods extended. Cap End only.
A53 & H53—Tie Rods Extended. Rod End only.
A54 & H54—Two Tie Rods extended at both ends.



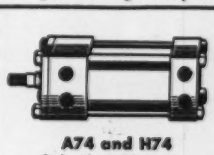
H65—Hydraulic Only
Flange Mounting on Rod End



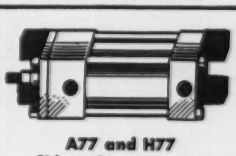
H66—Hydraulic Only
Flange Mounting on Cap End



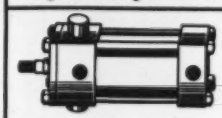
A72 and H72
Side Lug Mounting



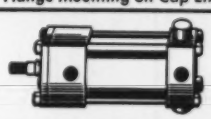
A74 and H74
Side Flush Mounting



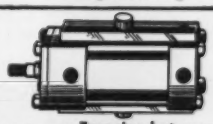
A77 and H77
Side or Foot Mounting



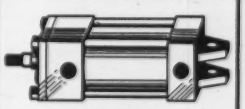
A81 and H81 Trunnion Mounting on Rod End



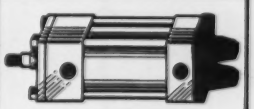
A82 and H82 Trunnion Mounting on Cap End



A83 and H83 Trunnion between Head and Cap
(one week delivery)



A84 and H84
Pivot Mounting



A86 and H86
Pivot Mounting

IN STOCK BORES

	Bores	Rod Dia.	Rod Turn Down & Threads	"IN-STOCK" STROKES (In Inches)																					
AIR	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12									
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12									
	2	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	2½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	3¼	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	4	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	5	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	6	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	8	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
HYDRAULIC	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12									
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12									
	2	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	2½	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	3¼	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	4	1¾"	1¼-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	5	2"	1½-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36

(1) (4) (3) (2)

"A" and "H" Models 82, 84 and 86 with strokes over 18" require stop tubes.

Column strength requires larger diameter piston rods for the following:

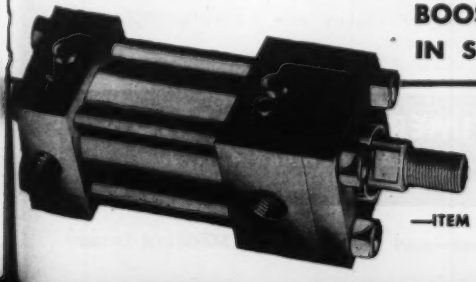
Air Cylinder Models A82, 84, and 86 with strokes inside area (1), when operated at 100 psi and over;

All hydraulic models with strokes inside area (2) and Models H82, 84, and 86 with strokes in area (4), when operated at 2000 psi and over;

Models H82, 84 and 86 with strokes inside area (3), when operated at 1000 psi and over.

Depending upon Trunnion Pin location, "A" and "H" Models 83 with standard diameter piston rods can have longer strokes than Models 82, 84 and 86.

See Miller File #251 for oversize piston rod and stop tube requirements.



BOOSTERS IN STOCK

Immediate Delivery on the following Miller 25 to 1 Ratio Boosters (80 psi air input produces 2000 psi hydraulic oil output): Model B4, 5" bore, 1" dia. ram, 6" and 12" strokes; Reciprocating Booster Model DA77-RBA8, 5" bore, 1" dia. ram, 6" stroke. Also Booster Tanks, 5" dia., 6" and 10" heights.

Write For Catalog and Stock Price List

—ITEM 553—

Miller

MILLER FLUID POWER DIVISION
FLICK-REEDY CORP.

2006 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

YOUR "SPECIAL" TIMER
may be one of our
721 STANDARD UNITS!

We have 20 years of experience in developing new timers to meet our customers' widely varying requirements. Our Engineering Department not only originates new designs, but also develops modifications for that purpose. That's why most requests for special timers can be filled without delay—by one of the 721 combinations we've developed so far from our 17 basic types of timers. But if we don't have what you want on hand, we'll welcome the chance to design and make it for you! And quickly too!

We manufacture a complete line of timers in these 4 broad classifications:

INTERVAL TIMERS • TIME DELAY TIMERS
RE-CYCLING TIMERS • RUNNING TIME METERS

Our large stock assures you of rapid deliveries—even when we have to create a brand new timer for your special needs. Ask us first—you may save yourself much lost motion... and your inquiry will receive prompt attention.

Timers that Control the Pulse Beat of Industry

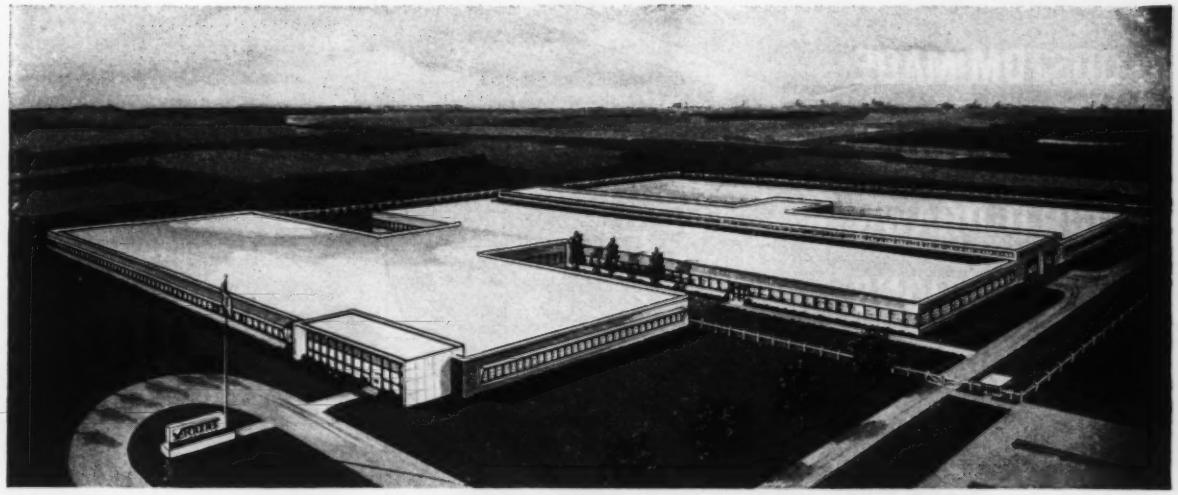
INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION
1413 McCARTER HIGHWAY, NEWARK 4, N. J.

—ITEM 554—
For More Information Circle Item Number on Yellow Card—page 19

VICKERS

NEW ADMINISTRATIVE and ENGINEERING CENTER



Dedicated to the **Development** and **Improvement** of **Hydraulic Components and Systems**

Vickers, a pioneer in oil hydraulics for a wide variety of uses, has maintained leadership through the years by means of aggressive and extensive research.

Continuing rapid expansion of the oil hydraulics requirements of industry has brought with it the need for augmented research and engineering facilities. To meet this need, Vickers has just completed this new building in suburban Detroit . . . 150,000 square feet devoted entirely to research, development, engineering application and administration.

A milestone in Vickers progress, this new Administrative and Engineering Center is also a promise of future benefits to users of Vickers hydraulic components and systems.

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DIVISION OF SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: **• ATLANTA • CHICAGO • CINCINNATI • CLEVELAND DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS TULSA • WASHINGTON • WORCESTER**
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

7385

Engineers and Builders of Oil Hydraulic Equipment Since 1921

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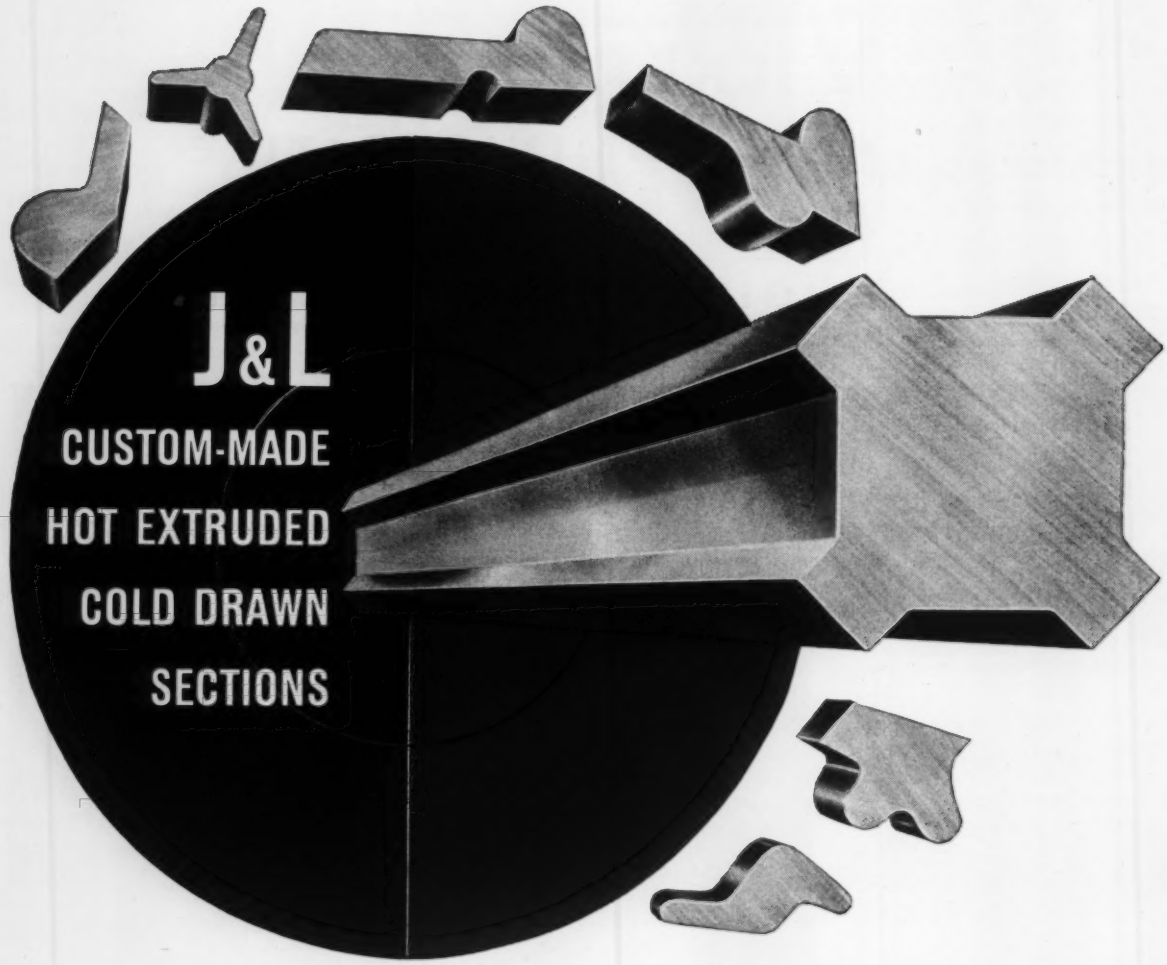
For More Information Circle Item Number on Yellow Card—page 19



...boost production, cut over-all costs

WRITE TODAY for your copy of this free new booklet which gives detailed information about the many money- and time-saving advantages J&L Extruded Sections offer you.

Jones & Laughlin Steel Corporation
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Please send me your new Booklet on Extruded Sections.

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1. **Eliminate time and costs** in machining and finishing operations
2. **Reduce scrap losses** practically to the zero point
3. **Eliminate the cost of castings and forgings** of intricate sections requiring considerable machining
4. **Reduce inventories** due to quick availability of extruded sections from the J&L plant

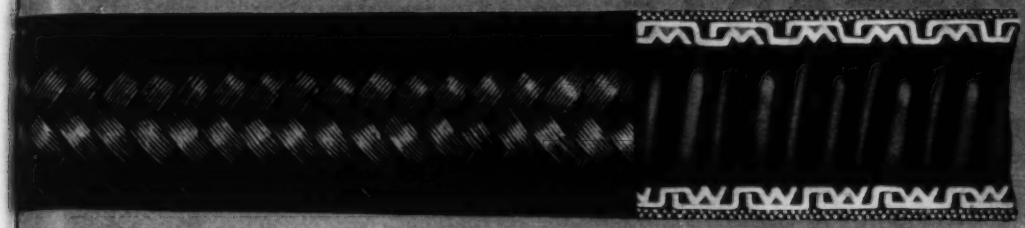
These sections can be extruded and cold drawn to the exact specifications of the parts you require—in any quantity you specify. Even the production of a single extrusion can be economical. Obtainable in a wide range of material grades, J&L Extruded Sections can be produced in a large variety of shape profiles—within limits of a design which can be inscribed within a two-inch circle. Many shapes that cannot be hot rolled are practical for the extrusion process.

The mechanical properties of J&L Extruded Sections are equal to or superior to those obtainable from equivalent grades conventionally cold drawn. Cold drawn tolerances are accurately maintained. The excellent surfaces of these Extruded Sections require little—if any—finishing operations.

Send us your inquiry for prompt and efficient J&L service.

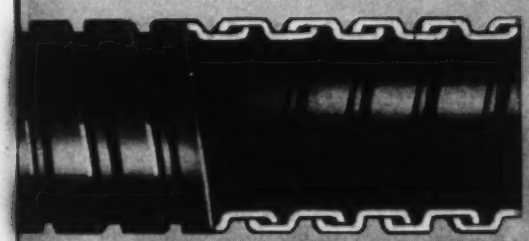
Jones & Laughlin
STEEL CORPORATION · PITTSBURGH

—ITEM 556—



TYPE FP WIRE BRAIDED

HEAVY DUTY INTERLOCKED



LIGHTWEIGHT SQUARELOCKED
Unpacked, cord packed, light asbestos packed, heavy asbestos packed

FLEXIBILITY

DEFIES HEAT...FATIGUE ABRASION...LEAKAGE

Penflex is ruggedly built hose with all of the flexibility required, plus the toughness and durability of metal. No matter how hot the material to be conveyed Penflex cannot be cooked like ordinary hose. It stubbornly defies rough abuse, abrasion and crushing.

From 1/8" I.D. to 24" I.D. . . . bronze, galvanized steel, or stainless steel . . . from an air compressor line to a diesel exhaust, Penflex makes them all for industry. And Penflex "Flexineering"—the science of applying flexible tubing to fit the particular needs of the job to be done—assures the right tube in each installation. When you require tubing or hose that is tight as a pipe, but flexible . . . safe at high temperatures . . . and free from metal fatigue, specify Penflex.

Penflex manufactures a complete line of four wall interlocked and seamless welded corrugated flexible tubing for industry. Write for your free copy of the booklet "Flexineering At Work."

Pennsylvania Flexible Metallic Tubing Company, Inc., 7239 Powers Lane, Phila. 42, Pa. *Branch Sales Offices:* Boston • New York • Chicago • Houston • Cleveland Los Angeles and Distributors in Principal Cities

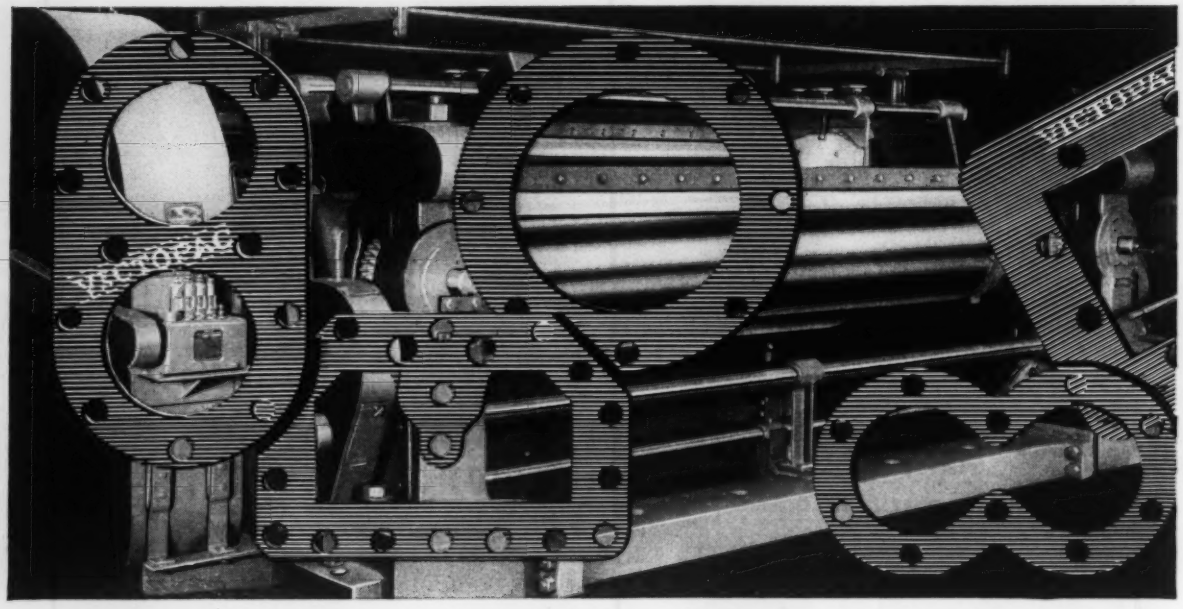
—ITEM 557—

HEART OF INDUSTRYS LIFELINES

PENFLEX

METALLIC TUBING

Now VICTOPAC for Everyone!



VICTOR doubles production of this versatile asbestos-synthetic rubber sheet packing

Sealing engineers agree on Victopac synthetic rubber and compressed asbestos sheet packing. Its known consistent performance on automotive and industrial applications has created unprecedented, still growing demand. By adding new specialized machinery, Victor has increased production and is now able to fill your orders promptly, whether for sheets or finished gaskets.

SERVICE RECOMMENDATIONS

Victopac is the proven economical specification for sealing hot or cold water . . . steam . . . vapor . . . combustion engine fuels, lubricants or coolants under high fluid and heavy flange pressures. It is a highly developed long-fiber asbestos-synthetic rubber composition, compressed and bonded under heat. In sheet form it is tough and completely homogeneous, with unlimited usefulness.

MEETS SAE-ASTM SPECIFICATIONS

In its several basic types, Victopac conforms to SAE-ASTM specifications G-1111, G-1122 and G-1123. Made in standard sheet thicknesses up to 1/8"—in sheet sizes up to 58" x 62 1/2".

TEST SAMPLE SHEETS SUPPLIED

Your inquiry invited for sample sheets. Please write on business letterhead, stating proposed application. See your Victor Gasket Engineering Catalog No. 505 for complete technical data.

Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. In Canada: Victor Mfg. & Gasket Co. of Canada Ltd., Victor Dr. and Chester St., St. Thomas, Ont.

VICTOPAC CONDENSED SPECIFICATIONS

Type	SAE-ASTM Spec.	% Compression 5000 p.s.i. Load	Recovery %	Minimum Original Tensile	Max. Thickness Change in ASTM Oil No. 1—5 hrs. at 300° F.
1	G-1111-1	12 ± 5	40	1800 p.s.i.	20%
1	G-1111-2	20 ± 5	40	1250 p.s.i.	20%
1B	G-1111-1	12 ± 5	40	1800 p.s.i.	20%
2 Graphite coated, one side	G-1111-1	12 ± 5	40	1800 p.s.i.	20%
3 Graphite coated, two sides	G-1111-1	12 ± 5	40	1800 p.s.i.	20%
50V	G-1122-1	12 ± 5	40	2000 p.s.i.	10%
60V	G-1123-1	12 ± 5	40	2000 p.s.i.	15%

VICTOR

Sealing Products *Exclusively*

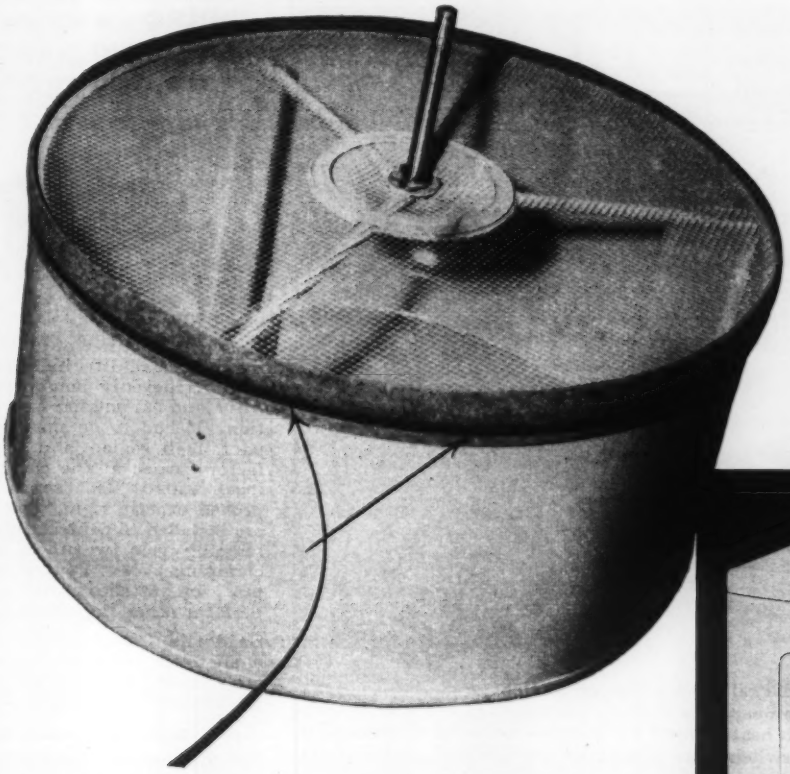
GASKETS • OIL SEALS • PACKINGS

—ITEM 558—

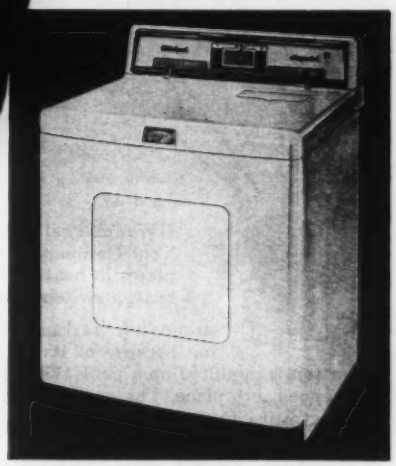
For More Information Circle Item Number on Yellow Card—page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



American Felt Company, Glenville, Conn., produces the seals for this RCA WHIRLPOOL dryer. Plain felt is used at the loading end; felt blended with Hycar latex is used at the damp exhaust end.



IMPROVED SEAL KEEPS A LOT OF HOT AIR AT WORK

AIR at the exhaust end of this RCA WHIRLPOOL dryer is not only hot but laden with moisture. Yet the seals must stay strong and resilient to keep this hot, moist air in the exhaust duct where it belongs, and maintain an effective barrier between the rotating drum and its cabinet.

Thus the seal manufacturer blended Hycar nitrile rubber latex into his felt material to provide a moisture-resistant seal that stands up under this service. And Whirlpool-Seeger reports: "the Hycar-treated felt is much more satisfactory than anything previously used".

Products made from Hycar, or from other materials blended with Hycar, answer many problems. They are highly resistant to moisture, oil, solvents, and chemicals . . . and show excellent aging properties.

For further information on Hycar rubber, write Dept. EJ-4, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

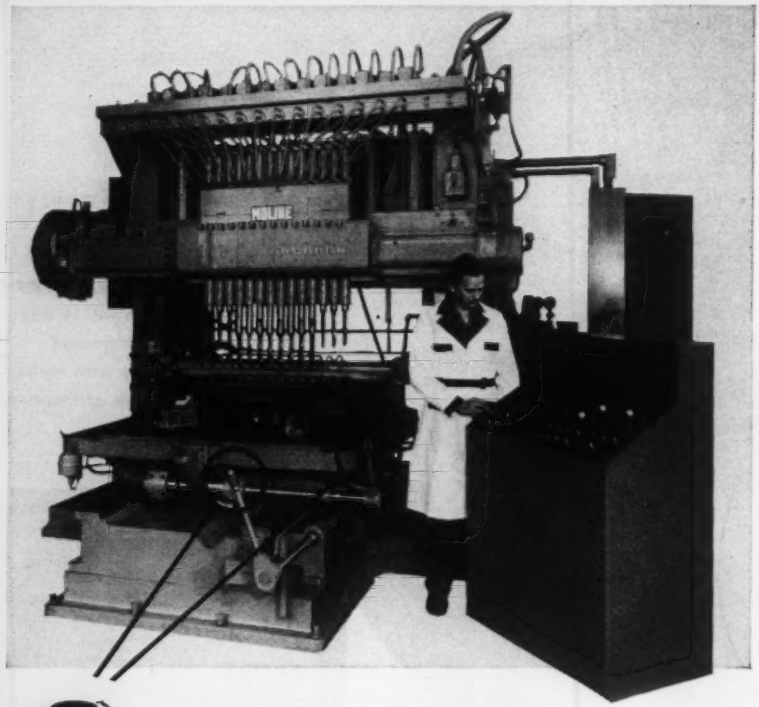
Hycar American Rubber

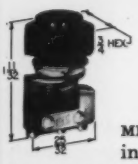
B.F.Goodrich GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

—ITEM 559—
For More Information Circle Item Number on Yellow Card—page 19

MICRO precision switches

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN





Hydraulic rail feed driller of Moline Tool Company for drilling, reaming and chamfering tube plates in heat transfer equipment. MICRO "PB" series push button switches are wired into the end of the hand levers.

MICRO "PB" series push button subminiature switch is outstanding because of its small size and the fact that after the push button is mounted on a panel, the switching unit can be wired and then easily snapped into place. The push button is sealed to keep dirt and moisture from penetrating to the back of the panel.

Sealed small-size subminiature push button switches are easily wired into lever handles of Machine Controls

Two MICRO "PB" series push button subminiature switches are used by Moline Tool Company on their HD68 machine for drilling header plates or tube sheets. A switch is located in the end of each hand lever to relieve hydraulic pressure and permit easy movement of the lever in turning the index bar to relocate the work table.

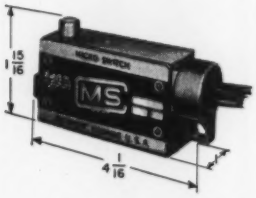
Moline Tool engineers selected these MICRO SWITCH units because of their small size, the fact that they are sealed to prevent dirt and moisture from penetrating the back of the panel and because they can be wired first and then easily snapped into place behind the panel.

Though small in size, these switches have the ruggedness to give reliable, precise operation as components for heavy machines and equipment.

Other MICRO precision switches of different types are used to control the automatic feed cycles of the drills, as a limit for the vertical movement of the drilling unit and to perform other important functions.

Send for Catalog 75
on "Subminiature Switches"

"MICRO's wide variety let us pick exactly the right switch"

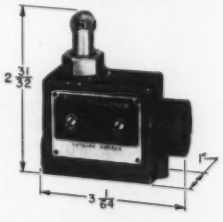


This manufacturer of an automatic reaming machine had to have a sturdy, ruggedly housed switch to withstand hammerlike impact actuation. It had to be small and compact, well sealed and with leads factory-sealed at the conduit openings. MICRO "LN" series switches proved exactly right. Two of them are installed to control depth of the reaming cycle, two others restart the clamping cycle. Four other MICRO precision switches of different types perform other important functions.

Said the Chief Engineer—"We came to MICRO SWITCH because their wide variety of switches let us select the switch best fitted to our need."

Send for Catalog 83
on "Industrial Enclosed Switches"

Accurate and rugged to guard dies on 250-ton press



Safety of expensive dies on a huge 250-ton press depend on the faultless performance of two MICRO precision switches.

Extremely accurate and enclosed in rugged die cast housings, the switches were chosen by the press designers for this highly critical function. The switches gauge the thickness of blanks fed into the machine at the rate of 1000 an hour. If more than one blank is fed in at a time, the switches stop the press instantly.

Send for Catalog 83
on "Industrial Enclosed Switches"

...have uses unlimited

HONEYWELL

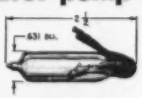
MICRO SWITCH
Engineering Service can be a short cut to better design

MICRO SWITCH Engineering Service is made up of experts on just one thing—precision switching problems.

Whatever your design problem, its solution may easily be expedited by consultation with an engineering service that has helped in the solution of many complex electrical switching problems.

MICRO SWITCH may have already solved a problem similar to yours—for somebody else. Should your problem turn out to be entirely new, MICRO SWITCH can—and will—develop the switch you need.

Environment-proof for water pump controls



Designers of liquid level and pressure controls for automatic pump controls found all five of the vital requirements for switches in such a device in Honeywell Mercury Switches.

These were: (1) high resistance to humidity; (2) unaffected by corrosive gases; (3) operation by low energy input; (4) capacity for wide overtravel; and (5) flexible in adjustment.

The switch used in this application is capable of a maximum tilt of 5 degrees. Switches are operated by revolving discs.

Send for Catalog 90 on "Honeywell Mercury Switches"

Absolute dependability—free from maintenance

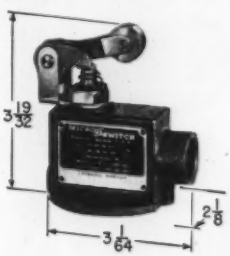
Wired into the shear gauge dial, two small but extremely rugged and reliable MICRO precision switches keep the travel of a giant metal shear within precise limits.

The designers required small, precise snap-action switches that must be accurate in performance, built for long-life operation and absolutely dependable—with little or no maintenance.

They found these vital factors in the MICRO precision switches selected. When the gauge has traveled to its maximum setting, the limit switch stops the motor and prevents damage to the back gauge screws. On the forward movement, the limit switch prevents the gauge from running into the shear knife.

Send for Catalog 62 on "Basic Switches for Industrial and Commercial Applications"

"No needle breakage since we installed the switches"



Sometimes it happens that a designer discovers a spot where MICRO precision switches will make his product better and more productive as a result of his customer's installation.

In this case a southern textile mill owner found a way to prevent needle breakage and reduce jams on his carrier rack by using MICRO precision switches.

One is installed so that it stops the machinery at once in the event of any misadjustment or mechanical failure. The other stops machinery if the narrowing fingers approach each other so closely as to tear up the needle bed.

Send for Catalog 83 on "Industrial Enclosed Switches"

How new "EN" Series Sealed switches provide Unusual design flexibility

MICRO Series "EN" switches are capable of reliable, long-life performance under extreme conditions. They are completely sealed, are cylindrical in shape and can be mounted wherever a through hole can be provided.

Roller plunger actuator for actuation by cams and slides
Spring return adjustable actuator for cam or slide actuation
Positive drive adjustable actuator for linkage operation
Plunger actuator for in-line motion actuation

Check Catalogs or Data Sheets Desired. Sign on margin, tear off bottom of page and mail.					
Catalogs					Data Sheet
75	83	90	101	62	105

MICRO SWITCH Engineering Service is available to help you select the exact switch to meet your design problems. Call the MICRO SWITCH branch nearest you.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Compare... and you'll buy VALVAIR

Single Solenoid Speed King built to JIC standards. Guaranteed against coil burnout for life of valve.

Perhaps you're puzzled over which make of valve to buy. Or confused by a welter of unsupported *claims*. Some valves feature this advantage, some feature that.

But put them all together. Sift fact from fallacy. Match actual performance *records*. Compare *quality*, *workmanship*, *guarantee*—and you'll arrive at one inescapable answer. It's —*Valves by Valvair*.

Add to this Valvair's alert sales-service organization in all leading industrial areas . . . Valvair's rapid delivery from stock. No matter what your requirements in air, hydraulic and vacuum control valves—specify *Valves by Valvair*. Valvair Corporation, 454 Morgan Avenue, Akron 11, Ohio.

AA-3247

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—ITEM 561—

For More Information Circle Item Number on Yellow Card—page 19

MACHINE DESIGN
August 9, 1956

They're Spending Our Money

ENGINEERING effort for national defense has largely created the current high demand for engineers. It is also responsible for a sizable chunk of our taxes. Magnitude of the effort is such that any improvement in efficiency, or otherwise, can have a profound effect on our national economy and security.

To many in industry the inefficiency of government seems fantastic. It is easy and popular to blame bureaucrats and politicians for the situation. Yet much of the red tape and frustration are inherent in the need for checks and balances to protect the public interest.

Unfortunately, the myth still prevails that the national treasury is a great reservoir of wealth from which a smart citizen should be able to divert as much as possible in his own direction or that of his company.

Thus Congress, in the public interest, finds it necessary to provide for strict accounting of expenditures by government agencies and to establish careful watch over them through the General Accounting Office.

In engineering work, particularly the research and development phases, it is notoriously difficult to predict costs or even to say whether a completed project has been worth what it did cost. This is hard for a layman—such as an accountant—to understand.

Because government contracts keep people busy at small risk, the temptation to spin them out is sometimes overwhelming. Possibly some engineering time is thus wasted; it is too easy to take advantage of uncertainties in evaluating creative effort in terms of time and manpower. But it is also natural for suspicions to arise when time and expense of a project exceed initial estimates.

It is wise to remember, in any dealings with government agencies, that behind them lurk publicity-seeking senators and congressmen eager for the excuse to conduct an investigation into any phase of government operation that promises national headlines.

In addition to denying the headline-seekers their opportunity, the engineer's sporting instincts might well prompt him to insure that he and his fellow-taxpayers are getting their money's worth.

Colin Carmichael

EDITOR

What's different about

Engineering on

By George W. Lupton Jr.
Attorney-at-Law
Los Angeles, Calif.

WHAT ARE the obligations of an engineer performing under a government contract? How are these obligations established, and how important are they? Where does the engineer fit into a government-contract engineering project?

An attempt to answer these questions usually brings to mind the necessity of interpreting pages of mysterious, confusing and complicated legal language. Actually, an overall view of the background of the development of government contracts along with a study of the objectives the government is trying to achieve will bring to light the answers to these questions.

Background of Government Contracting Policies

Law and regulations have been changed in recent years to require top-quality performance from all government contractors, including their engineering work. Previous to World War II, Congress had enacted a number of statutes dealing with various special phases of the government's contracting processes.

Immediately after World War II, Congress reviewed this large number of disconnected and confusing statutes dealing with federal procurement. It took steps to clarify and simplify the entire procurement picture by passing three statutes. These statutes are today the foundation of the entire contracting process.

The first of these statutes, the Armed Services Procurement Act of 1947, represents a comprehensive revision of the procurement laws.

The second of these statutes, the National Security Act of 1947, established the Department of Defense as an Executive Department. The Army, Navy and Air Force were made separate Military Departments within the Department of Defense. Among many other objectives achieved was a method of standardizing the rules and regulations of the three Military Departments by giving the Department of Defense the power to prescribe uniform procurement regulations for all three.

The third statute, the Federal Property and Administrative Services Act of 1949, created the General Services Administration, which, as the government's "housekeeper," does most of the buying for the "civilian" or nonmilitary needs of the government.

These three basic statutes, together with a few other related statutes dealing with special subjects, constitute a sturdy skeleton for the procurement body. Its flesh and blood is supplied by the detailed regulations of each of the procuring agencies, consonant with the basic statutes.

Basis of Armed Services Procurement: Immediately after the Defense Department was created in 1947, it embarked on a program to standardize procedures and the form and content of contracts. Regulations now establish uniform policies and procedures relating to the procurement of supplies and services by the three military departments. These regulations are known as "Armed Services Procurement Regulations" or, popularly, "ASPR." The first edition of ASPR became effective May 19, 1948. Since then, numerous supplements and revisions have been issued.

ASPR now consists of sixteen major sections and four technical appendices. Section headings, Table 1, give a birdseye view of the scope of this important document.

Of most interest to engineers is the fact that ASPR prescribes the exact wording of a large number of the clauses that must be, or may be, used in all Army, Navy and Air Force contracts. Also, ASPR establishes major policies and general

Government Contracts

Factors that influence an engineer's performance on government projects

- **Government objectives—price, quality, on-time delivery**
- **Regulations specifying method of performance**
- **Procedure in handling contract additions and changes**

procedural guides to be followed by the contractor and by the government.

Supplementary Regulations: In addition to ASPR, the Army, Navy and Air Force have each issued a parallel and supplementary set of regulations. These sets of regulations conform strictly to the provisions of ASPR, but additional detail or explanatory matter is frequently included.

The "Army Procurement Procedure" (APP) was issued in March, 1951, and reissued in revised edition in May, 1954. The recently published "Air Force Procurement Instructions" (AFPI), is keyed to ASPR, and contains an additional large amount of detailed regulatory matter. A completely revised edition of "Navy Procurement Directives" (NPD) was recently issued.

Other agencies, including the Atomic Energy Commission, the General Services Administration, and the Coast Guard, also have formal procurement regulations, but they all comply strictly with a common set of basic concepts. With few major exceptions, the prescribed procedures are the same or very similar.

Table 1—Armed Services Procurement Regulations

Section No.	Title
I	General Provisions
II	Procurement by Formal Advertising
III	Procurement by Negotiation
IV	Co-ordinated Procurement
V	Interdepartmental Procurement
VI	Foreign Purchases
VII	Contract Clauses
VIII	Termination of Contracts
IX	Patents and Copyrights
X	Bonds and Insurance
XI	Federal, State and Local Taxes
XII	Labor
XIII	Government Property
XIV	Inspection and Acceptance
XV	Contract Cost Principles
XVI	Procurement Forms

Despite the clarity of statutes, regulations and standard clauses, disputes between the contractor and the government frequently arise over the meaning and effect of standard clauses in particular cases. Consequently, provision has been made in a standard "disputes" clause, contained in each contract, for an expedited appeals procedure before an appeals board. The contract requires the contracting officer to make a decision in each instance of a dispute, and provides that the contractor can appeal from that decision if he is dissatisfied.

Objectives of a Government Contract

Regulations governing the procurement activities of the Army, Navy and Air Force state plainly the prime objective of the government in letting contracts. These regulations specifically require the three military departments to make contracts "which will be the most advantageous to the Government, price, quality, and other factors considered." In addition, the regulations prescribing procurement procedures are designed to guarantee "full and free competition" for the contracts the government awards, either on a bid basis or through negotiation with competing concerns.

Three fundamental facts stand out. First, the government has stated plainly that it is interested only in contracts that are advantageous to it and that it will compel full and free competition between contractors. Contracts that are "advantageous" to the government may be advantageous either (1) because the contractor's price is lower than his competitor's, (2) because his product is

Military Procurement Policies

Basic policies and objectives of government agencies in awarding contracts are spelled out in a series of regulations. Quoted here are excerpts from the Armed Services Procurement Regulations outlining factors to be considered by the agency before awarding a contract. Each contracting officer is required to give "due attention" to these and "any other appropriate factors":

1. Prices quoted, and consideration of other prices for the same or similar supplies or services, with due regard to production costs, including extra-pay shift, multishift and overtime costs, and any other factor relating to price, such as profits, cost of transportation, and cash discounts.
2. Business reputation, capabilities and responsibilities of the respective persons or firms who submit quotations.
3. Quality of the supplies or services offered, or of the same or similar supplies or services previously furnished, with due regard to the satisfaction of technical requirements.
4. Delivery requirements.
5. Discriminating use of price and cost analyses.
6. Price aspects of any important subcontract.
7. Individual bargaining, by mail or by conference.
8. Cost sharing.
9. Effective utilization in general of the most desirable type of contract, and in particular of contract provisions relating to price redetermination.
10. Size of the business concern.
11. Whether the prospective supplier is a planned producer under the industrial mobilization program.
12. Whether the prospective supplier requires expansion or conversion of plant facilities.
13. Whether the prospective supplier is located in a surplus or scarce labor area.
14. Whether the prospective supplier will have an adequate supply of qualified labor.
15. Extent of subcontracting.
16. Existing and potential workload of the prospective supplier.
17. Broadening the industrial base by the development of additional suppliers.
18. Whether the contractor requires government-furnished property, machine tools, or facilities, or government-operated test facilities.
19. Contract performance in facilities located in dispersed sites.

better, or (3) because his delivery schedules will best satisfy the government's requirements timewise. Other factors are generally incidental, or subsidiary, to these three principal elements in the award of a contract.

Second, concerns engaged in government work are in a constant competitive battle for contracts with other contractors. The government decides who shall be the victor by applying three tests: price, quality, and on-time delivery.

Third, the individual engineer is the deciding factor in this battle. His solutions to design problems must result in cheaper and easier to produce products. In performance, these products must be equal to or better than those of his competitors. Reports submitted on research and development contracts must be completed faster and at less cost to the government, and must be more valuable and authoritative than those of other engineers.

Place of the Engineer

Legal obligations of the engineer in connection with the performance of a government contract involving engineering work are usually defined in the contracts. Engineering services, because of their very nature, cannot be as specifically described in a contract as can a physical object. Contract clauses specifying engineering work frequently indicate what is wanted as the end product of the engineering effort, not how the work is to be done.

Engineering Requirements: Any contract requiring engineering design or development work also requires, by implication, the exercise of the engineer's professional imagination and judgment, and the full use of all his experience. There are factors that cannot be too accurately described in the specialized language of the lawyer. However, they are encompassed by typical clauses found in contracts requiring engineering work, such as:

> "The Contractor shall supply the necessary personnel, *qualified professionally* or otherwise, facilities, materials, and supplies, and shall perform a research study in accordance with Exhibit A."
>
> "The Contractor warrants that the services rendered in the performance of this contract will conform to the requirements of this contract and to *high professional standards in the field.*"

Method of Performance: Air Force cost-reimbursement research and development contracts contain a definition which seems to allow the engineer wide latitude in how his work shall be done. It reads:

> "The term 'contract work' means all work to be performed under this contract, including studies covering fundamental, theoretical, or experimental investigations, any extension of the investigative findings and theories of a scientific or technical nature into practical application; any tangible items, hereinafter referred to as 'supplies,' if called for herein, furnished to the Government; and any reports, data, computations, plans, drawings, and specifications with respect to any of the foregoing."

Despite the failure of most contracts to define exactly the "how" of the work, it is the engineer's duty to produce the end engineering product. But no more and no less. If the engineer does more work than the contract requires, the contractor will not be entitled to payment for the unauthorized extra work, either under a fixed price or a cost-reimbursement contract. To perform less than the contract requires is a breach of the contract for which the contractor is legally responsible.

Ambiguous Contracts: If the contract is ambiguous or vague in its description of the work to be done, including engineering work, the contractor should obtain a clarification from the contracting officer. Failure to do so may result in doing more or less work than the government wants done. Engineers confronted with an ambiguous or vague statement in a schedule should immediately obtain clarification from the contracting officer.

Frequently an engineer discovers that the schedule is inadequate to cover some additional phases of the job that should be done in order to deliver a properly finished job. In such cases, an appropriate Change Order, Amendment, or Supplemental Agreement will cover such additional work and provide for adequate additional payment. Obviously, the engineer should not spend his time on such additional work unless specifically authorized.

Performance Deadlines: Many contracts specifically require that engineering data be submitted to the government. In research and development contracts the entire performance may consist of the submittal of reports and various types of substantiating data. Production contracts usually require the submittal of engineering data of many kinds. In both cases, failure to deliver the specified data strictly in accordance with delivery schedules in the contract is a breach of the contract for which the contractor is responsible.

Every Government contract prescribes specific performance dates, if the nature of the contract permits. The on-time completion of the engineering work specified in a contract is as important as the on-time delivery of the physical end item. Proof of completion of the engineering work usually consists of the delivery of drawings and other data on specified dates. Contracts and regulations are explicit as to the legal effect of a failure to

Air Force Contract Requirements

Air Force procurement policies and objectives closely parallel those of other agencies. Generally, the prevailing thought behind these statements is to assure the government the most for its money in keeping with fair and sound business practices. The Air Force policy statement reads:

"The primary objective of the forward purchasing policy is to attain and maintain on a continuing basis an Air Force in a maximum state of readiness to perform its combat mission within approved force structures, with a minimum cost impact on the United States economy. The control of expenditures through employment of efficient inventory control procedures and purchasing methods, are indispensable prerequisites to the achievement of this objective. The Air Force must demonstrate continually increased efficiency in its current operations in addition to developing sound programs directed towards greater efficiencies in the future." Consistent with the above, the following requirements are established:

"1. Procurement will not be placed earlier than necessary to meet the requirements and/or maintain continuity of production.

"2. All procurement will be in accordance with the latest production reserve policy. This applies to both prime contractor and subcontractor complexes of aircraft and to all manufacturers of related equipment.

"3. No new contract is to be placed until the price, delivery, and quality elements of the purchase have been carefully reviewed and analyzed.

"4. Where contractors have delayed without justifiable cause or failed to negotiate in good faith prompt contract formalization, price redetermination, and target reset or final price revision under incentive contracts, and it is determined, after suitable review, that such delinquencies exist, no new contracts are to be placed with the contractors involved until the delinquencies have been corrected.

"5. Careful consideration is to be given to tightening the terms and conditions of new contracts and to insure that obligations undertaken by contractors are clearly stated and enforced. Increasing emphasis is to be placed on fixed price contracts, and wider use of incentive type contracts where it can be anticipated that lower over-all cost will result.

"6. Reasonable administrative controls or other assurances will be utilized to insure that the AF contractors maintain minimum inventories required for production consistent with sound business practices."

deliver the technical data on or before the date specified in the contract.

For example, Air Force regulations (AFPI 53-103.2) provide specifically that if technical and/or engineering data are required by the contract, the contract "will not be deemed to be fulfilled until delivery and acceptance of the data." Finance offices are required to withhold final payment under the contract until the data have been delivered and accepted.

Efficient engineering performance is manifested in many ways. Failure of the draftsman to make the lines and lettering on his drawing sufficiently heavy to permit easy reproduction may delay the submittal of engineering data. If the draftsman's drawing is not sufficiently legible it may be necessary to "heavy-up" his lines and lettering before acceptable prints can be made. Similarly, failure to indicate clearly the nature of the changes in the revision block, the crossing out of old revision blocks when adding new changes, or the splicing of vellums to accommodate changes may delay prompt performance of the data-submittal requirements of the contract.

Contract Changes: A large amount of engineering work is done because of changes in the configurations of large and complicated end items, such as aircraft or missiles, or in the design of their components. Because of the importance of this phase of engineering work some of the legal aspects of the "changes" procedure should be of interest to engineers.

Each contract contains a "changes" clause prescribed by ASPR. By its terms the "contracting officer may at any time, by a written order, . . . make changes, within the general scope of this contract, in any one or more of the following: (1) drawings, designs, or specifications, where the supplies to be furnished are to be specially manufactured for the Government in accordance therewith; (2) method of shipment or packing; and (3) place of delivery."

If changes cause an increase or decrease in price or in the time required for performance, the contracting officer must make an equitable adjustment. If he does not, the contractor may make a claim for adjustment, usually within thirty days but sometimes sixty days, after receipt of the Change Order. If the parties cannot agree on the amount of the price adjustment or on performance time, the dispute may be appealed to the appeals board. However, the contractor must proceed with performance of the contract as changed.

Additional Agreements: Air Materiel Command, Air Materiel Command field procurement activities, and Air Research Development Command are required by regulation to effect changes to contracts by amending such contracts with appropriate Supplemental Agreements or Change Orders in advance and prior to the times any such changes become effective, except in certain specific cases.

In these exceptional cases, Contract Change Notifications (CCN's) may be issued only when the urgency of the situation precludes the negotiation and execution of an appropriate Change Order or Supplemental Agreement. These cases include changes:

1. Involving safety to life and/or property.
2. Directed by Headquarters.
3. Of an emergency nature, essential to operation and/or maintenance, or necessary for furtherance of an experimental or development program.
4. To authorize acceptance of airplanes or equipment with shortages.
5. Involving no additional cost to the government and not affecting performance guarantee, time of delivery, or time of performance.

A Supplemental Agreement is to be distinguished from a Change Order. A Change Order can change only drawings, designs, or specifications, method of shipment or packing, or place of delivery. A Supplemental Agreement can cover any subject agreed upon by the parties so long as it does not change the basic contract and does not defeat the statutes requiring competitive bidding.

Engineering Under Subcontracts

Engineering work performed under a subcontract to a government contract is usually subject to the same conditions as work under a prime contract, plus additional requirements imposed by the prime contractor. The basic requirements of high quality, low cost, and on-time completion of engineering work are still as critical. Consequently, subcontracts have much the same elements of rigidity as prime contracts. However the prime contractor is not limited as to contractual obligations he can impose upon the subcontractor.

Therefore, the contractor may insist on numerous requirements not usually found in government prime contracts. For example, the work of the subcontractor's engineers is often subject to constant and close scrutiny by the engineers of the prime contractor. Approval of every step in the design may be required as well as frequent submittal of detailed engineering data or calculations.

Despite these additional requirements, subcontracts are usually more informally admistered than prime contracts. Technicalities concerning compensation are generally more easily adjusted.

Tips and Techniques

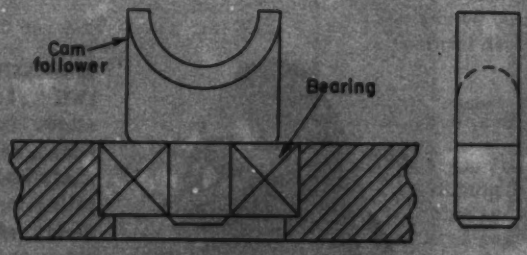
Preventing Eraser Burn

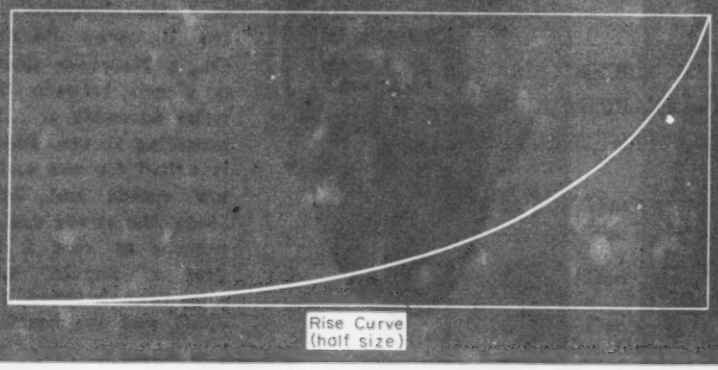
When using an automatic electric eraser, place a sheet of thin-gage metal under the paper. This will help dissipate the heat generated by the eraser and reduce the possibility of the eraser burning through the paper. — RICHARD MARSH, *Lima, O.*

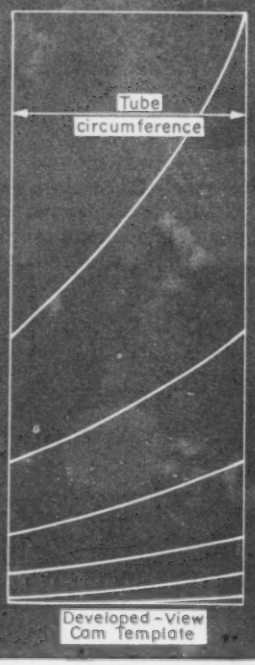
scanning the field for *Ideas*

SOLDERED-ON WIRE CAMS simplify development and fabrication of working profiles. Developed by Richard E. Shafer of Pasadena, Calif. and John G. Gertig of Northridge, Calif. for a recording device application, the construction is especially suited to applications where extreme precision is not required.

To make a cam, a developed-view template of the cam path is drawn on paper using a drawing of the complete rise curve as a pattern. This developed view is transferred to a tubular metal body photographically or by small punch marks. The wire is then carefully hand-stretched on the tube to conform to the desired cam path and soldered in place.



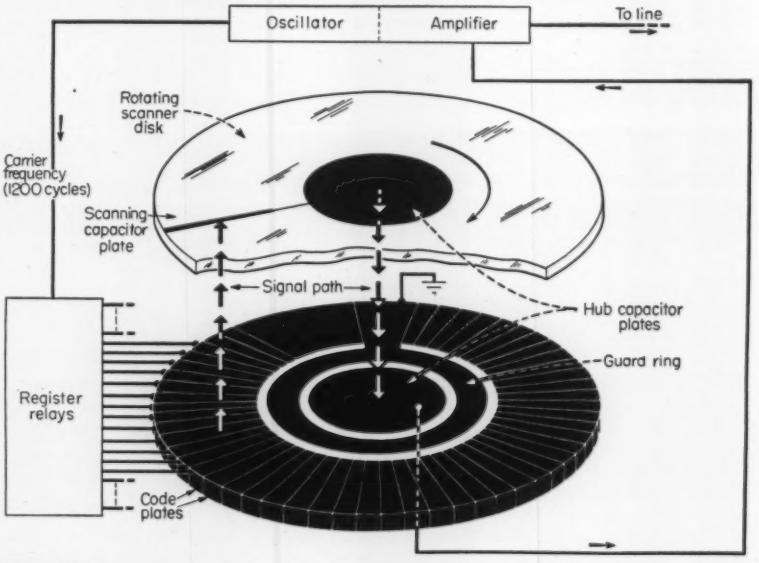


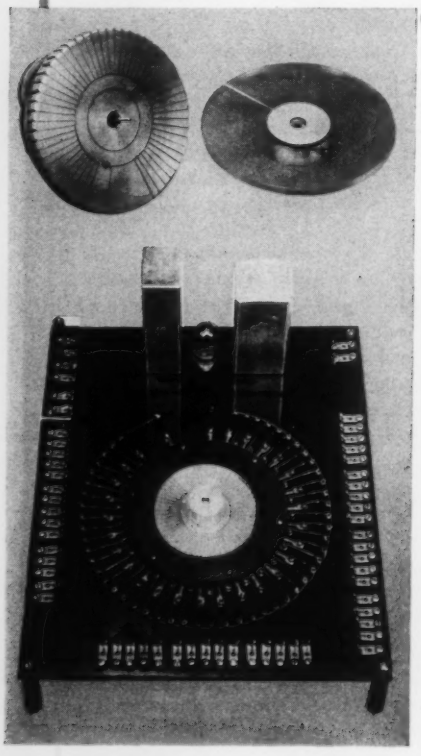


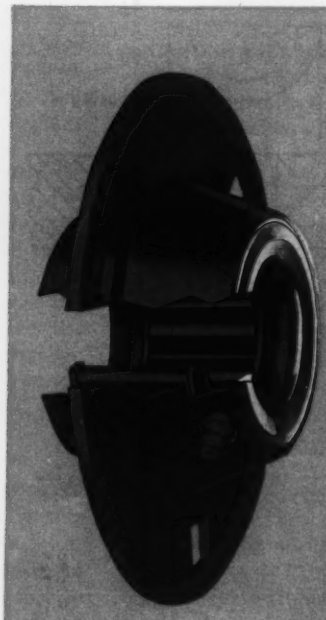
IDEAS

ULTRAHIGH-SPEED SWITCHING of electrical circuits is accomplished in a contactless, rotary switching assembly that employs a capacitive "slip ring." Developed by G. A. Backman of Bell Telephone Laboratories Inc. for electrical equipment used to transfer stored signal information to telephone transmission lines, this capacitor scanner can transmit 100 digits per second.

Basically, the switching unit (scanner) is composed of stationary and rotating disks. The stationary disk consists of a group of radial code plates mounted around the periphery of a guard ring and a hub-capacitor plate assembly. The guard ring prevents leakage to the hub plate. The rotating disk contains a small scanning capacitor plate electrically connected to a second hub - capacitor plate. Certain of the fixed code plates, depending on the dialed number being transmitted, are supplied with a voice-band carrier frequency by the contacts of the register relays that store the dialed information. A voltage is produced in the rotating scanner plate as it passes over each of these energized code plates. This voltage is conducted to the rotating hub-capacitor plate and then, by the principles of electrical capacitance, is detected by the stationary hub-capacitor plate, amplified, and applied to the line as a signal.







FLEXIBLE MOUNTING FLANGE design allows for slight axial misalignments between shaft and hub type rotating members. In the design of flexible cartridge type roller bearings manufactured by the Rollway Bearing Co., a Neoprene sleeve is placed between the roller assembly and the mounting flange. Ideally suited for use under low speeds and light loads, the sleeve design permits at least 1 degree of angular misalignment between the shaft and the housing.

Drafting Short Cuts

13 suggestions for saving drawing time

By Stanley J. Burwell
Product-Development Engineer
Walker-Turner Div.
Kearney and Trecker Corp.
Plainfield, N. J.

REDUCING the number of man hours expended in the making of drawings is a worthwhile objective anytime. Today it is particularly applicable. Ways of saving time run all the way from photocopying, in various forms, to the abbreviation of the picture of the drawing itself. All have their places and should be used when they suit the occasion.

One of the larger wastes in drafting time lies in making drawings more complete and exact than their purpose demands. This fanciness is a costly luxury which can and should be reduced to a minimum.

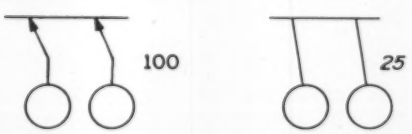
The accompanying 13 suggestions cover a number of drafting tricks which, though small in themselves, collectively add up to substantial savings in a draftsman's time. These tricks are not original. Some have been used by architects, civil engineers, structural detailers, and magazine illustrators. Most

1. Don't draw borders on the paper. Just omit them if they are not printed on.

2. Don't draw in title blocks. Use a rubber stamp, or just letter in the minimum information without boxes, separators, or underlines.

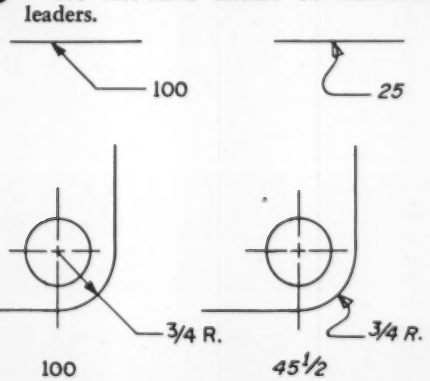
3. Don't blacken in arrowheads.

4. Don't put arrowheads on balloon leaders.

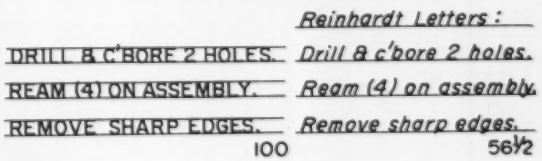


5. Make all dimensions and notes read from bottom of sheet.

6. Use free-hand instead of instrument leaders.



7. Don't use upper-case lettering. Instead use sloping lower-case letters (Reinhardt) to save time and for easier reading. Used commonly by civil engineers, the Reinhardt style is based on two elements: straight line and ellipse.

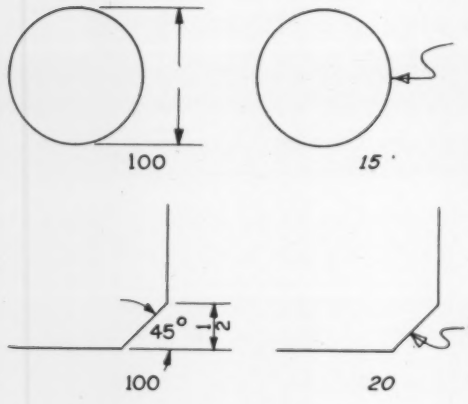


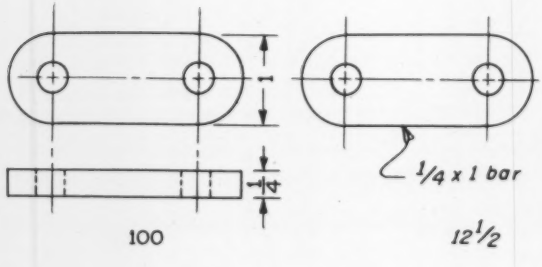
8. Don't draw guide lines above *and* below lettering. Do without, or use only the bottom one.

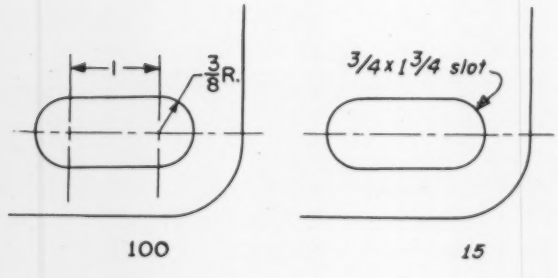
9. Don't underline lettering.

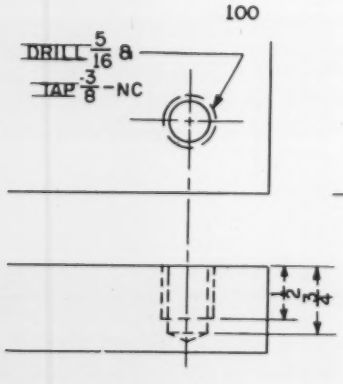
10. Don't use several different grades of pencil. One fairly soft one, kept sharp, will do for everything.

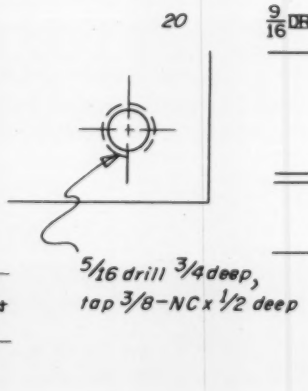
11 Don't use dimensions when a note will give the same information.

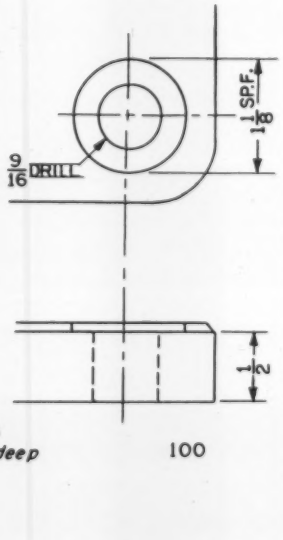


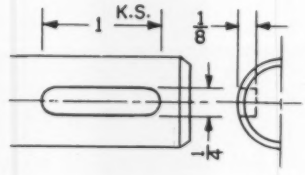


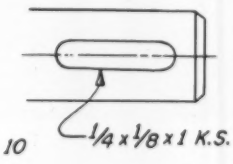


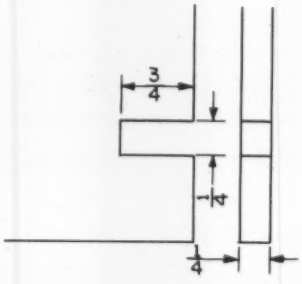


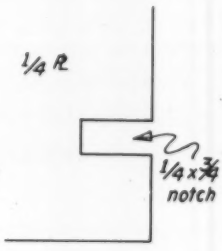










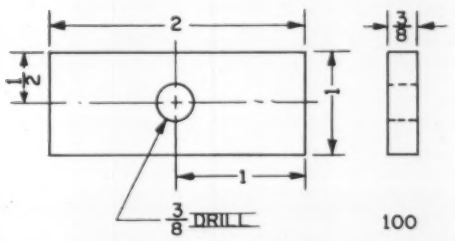


are not, however, currently in common use for mechanical drawings.

These methods, largely free-hand, are not a cure-all for excessive drafting time. They do, however, provide substantial time savings in the design of small and medium-sized experimental mechanisms and special machines. The advantage of free-hand drafting is doubtful, however, when lines of more than a foot in length must be drawn.

In the illustrations, the numbers represent relative drafting times and apply only to those parts of the illustrations which show differences between the conventional and the short-cut method.

12 Don't use dimensions from centerline unless they are essential. The centerline symbol serves just as well in most cases.



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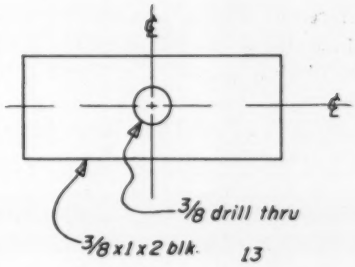

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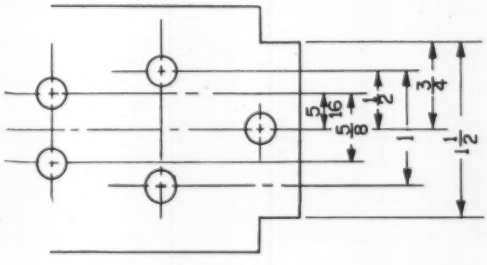

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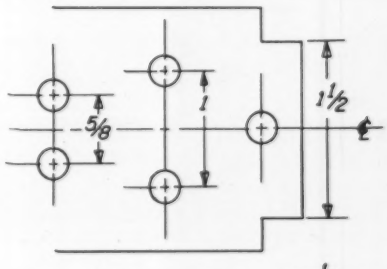
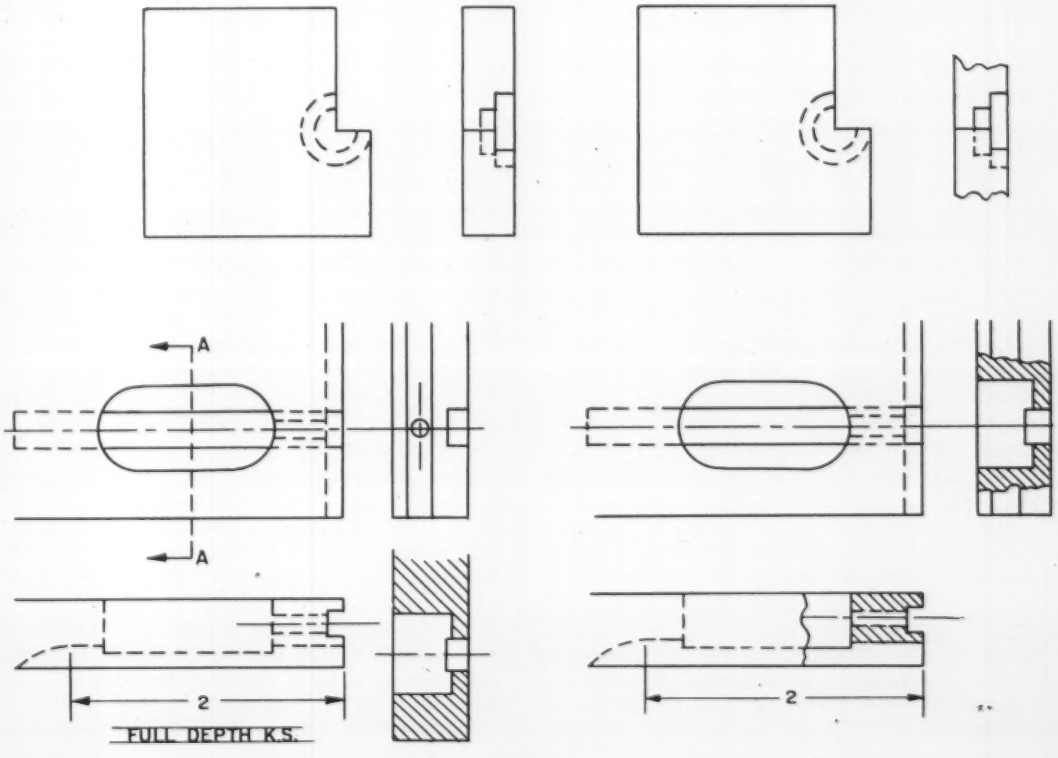


37 1/2

13 Don't make full auxiliary views of sections when partial ones will serve the purpose.



Digital and analog computers differ substantially in accuracy, versatility and cost—the differences arising primarily from fundamental differences in the two methods of computation. The design engineer attempting to evaluate these time-saving aids to engineering analysis must keep in mind that each computer type is best suited to its own field of application. Rarely can a specific problem be solved with equal facility and speed on either machine.

Digital computers—which represent problem numbers by integral numbers of electrical pulses —are inherently more accurate than analog machines. If solution time permits, high digital precision is attained simply by increasing the number of pulses used to represent a number. Depending upon the complexity of the problem, precision to the order of 0.01 per cent can readily be developed.

Although less accurate, the analog computer is much faster for some problem classes than the digital type; furthermore, it is generally the cheaper of the two. Initial analog machine cost —because it is primarily a function of the complexity and quality of the analog circuitry—rises rapidly with precision that is demanded. If errors from 0.1 to 10 per cent are acceptable, analog machine cost will usually be less than for the digital machine.

Best application of the digital computer is in the large-scale, repetitive computation area where a high degree of accuracy must be main-

Principles and Design Uses for

Analog Simulators

Part 1—Analog Components and Mathematics

ANALOG devices — whether computers, simulators or analyzers—share a common family characteristic: numbers in the problem to be solved are represented by corresponding physical quantities in the machine. Slide rules, for example, represent problem numbers by scale lengths that are proportional to the logarithms of the numbers. Similarly, the dc analog computer translates problem numbers into corresponding network voltages, either constant or varying with time.

In this article, the first of two dealing with the analog simulator in design, basic simulator arithmetic is introduced and related to the functions of the electronic analog circuitry. How these fundamental operations are applied to the solution of simple linear and nonlinear equations is also outlined.

In an article following this one, application of the electronic simulator to system studies of single and multidegree of freedom vibrating systems is demonstrated.

Basic Simulator Operations: The electronic analog simulator or computer is primarily of greatest utility in determining the response of systems which may be described by linear differential equations. The basic operations which the electronic analog simulator must perform in this process of solving a linear differential equation are: (1) addition of several terms, (2) multiplication by a constant, and (3) integration of a variable with respect to time.

These basic operations all involve the use of an operational amplifier, which is merely a very high-gain, direct-coupled amplifier with low drift or low zero change with time. The use of the operational amplifier is based upon the input and output voltage relations which exist when the input voltage is fed through an input impedance z_i and the output voltage is fed back to the input side of the amplifier through a feedback impedance z_f as indicated in Fig. 1.

Input-output voltage relationships for the circuit

tained. The digital machine, requiring a central pulse-generating unit, has a certain minimum size; consequently, the economics of the computer design dictate that the machine shall be on the large, high-capacity side. Programming the digital machine usually requires more mathematical skill than for the analog, and often is carried out by a central computing staff. Changes in system parameters are somewhat difficult to make, particularly during the course of a solution.

Electronic analog machines range in size from one-man desk models, incorporating ten to fifteen amplifiers, to large installations using hundreds of amplifiers, considerable associated equipment, and requiring a large staff for maintenance and operation. In the small category, the analog machine is less expensive to run and maintain than the digital type; for installations of the same general size, operating costs are comparable.

The analog computer is especially suited for limited-accuracy design studies of dynamic systems. Programming on the analog machine is reasonably simple and can be carried out by personnel with routine training in engineering or physics. Parameters and coefficients basic to the problem, as well as initial conditions and forcing functions, can be quite simply varied while the problem solution is in progress. This feature is of particular value in design studies requiring trial solutions for design parameters.

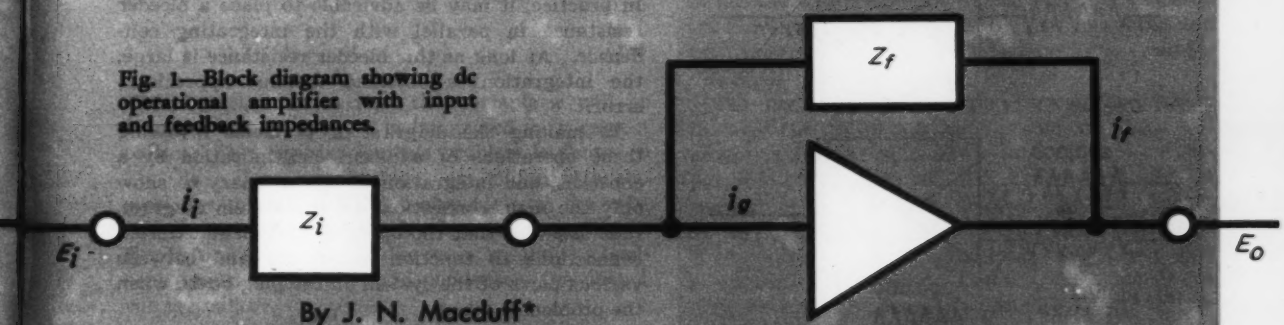


Fig. 1—Block diagram showing dc operational amplifier with input and feedback impedances.

By J. N. Macduff*
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Rensselaer Polytechnic Institute, Troy, N. Y.

of Fig. 1 are found from the usual premise that the current i_g flowing into the grid of the first tube of the amplifier is very close to zero. It should also be noted that the operational amplifier has a gain of 20,000 or more. Since the sum of the currents at any junction must be zero, the current relationship for this system is

$$i_i + i_f = i_g = 0 \qquad (1)$$

Replacing the currents with their equivalents in terms of voltage and impedance gives

$$\frac{E_i - E_g}{Z_i} = -\frac{E_o - E_g}{Z_f} \qquad (2)$$

Grid voltage in terms of the output voltage and amplifier gain G, which is a large number, is

$$E_g = \frac{E_o}{G} \approx 0 \qquad (3)$$

Combining Equations 2 and 3,

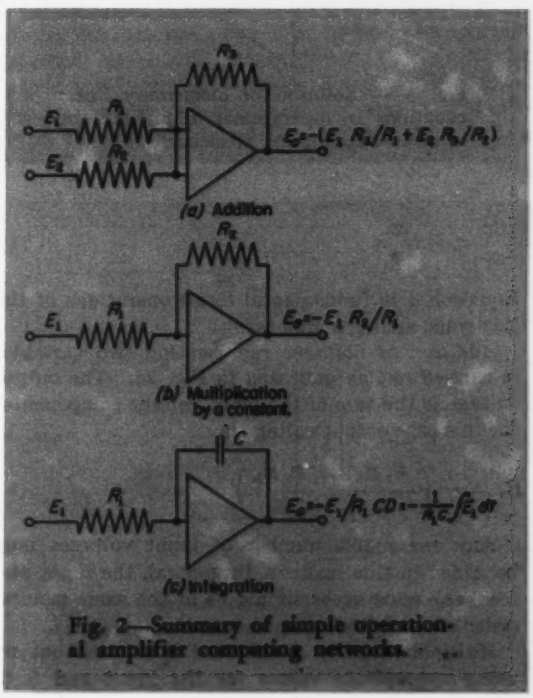

Fig. 2—Summary of simple operational amplifier computing networks.

*Now at Duke University, Durham, N. C.

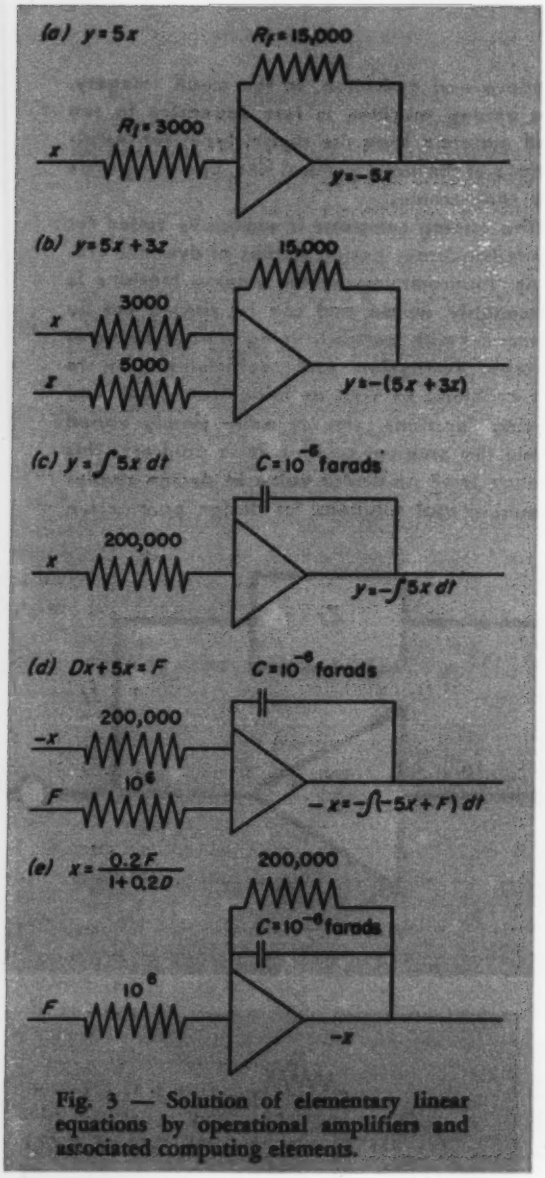

Fig. 3 — Solution of elementary linear equations by operational amplifiers and associated computing elements.

$$\frac{E_o}{E_i} = -\frac{Z_f}{Z_i} \tag{4}$$

Equation 4 is fundamental to all operations of the electronic analog simulator.

Addition of voltages representing two variables is carried out as indicated in Fig. 2*a*. The output voltage is the sum of the input voltage components; for this case output voltage is

$$E_o = -\left(\frac{E_1 R_3}{R_1} + \frac{E_2 R_3}{R_2}\right) \tag{5}$$

Any reasonable number of input voltages may be added in this manner. In general, the input and feedback resistances should be of the same general order of magnitude.

Multiplication by a constant is carried out by using appropriate values for the input and feedback resistors as indicated in Fig. 2*b*. For this system, the output voltage is

$$E_o = -\frac{E_1 R_2}{R_1} \tag{6}$$

Thus, output voltage is equal to input voltage (with a sign change) multiplied by the ratio of the feedback to input resistances used.

Integration with respect to time is attained by using a condenser for the feedback impedance as shown in Fig. 2*c*. Impedance z of the condenser in operator form is

$$Z = \frac{1}{CD} \tag{7}$$

Where C = capacitance, farads; $D = d/dt$. Output voltage is given by

$$E_o = -\frac{E_1}{R_1 CD} = -\frac{1}{R_1 C}\int_0^t E_1\, dt \tag{8}$$

In practice, it may be advisable to place a bleeder resistance in parallel with the integrating condenser. As long as this bleeder resistance is large, the integration is obtained without appreciable error.

In making the diagram of problems involving these operations of addition, multiplication by a constant, and integration, it is customary to show only the main connections on the system diagram. It is assumed that the operator will make external connections to function generators and between various parts of the system on the plug board when the problem is set up.

Elementary Linear Applications: Application of the analog simulator to linear problems is based upon Equation 4 and upon Equations 5, 6 and 7 derived from this relationship. To perform an operation such as

$$y = 5x \tag{9}$$

let x be a voltage which may be varied by the operator. This voltage is applied as an input voltage through an input resistance R_i, as illustrated in Fig. 3*a*. If the feedback resistance, $R_f = 5R_i$, the output voltage will be $y = -R_f/R_i\, x = -5x$.

To solve an equation such as

$$y = 5x + 3z \tag{10}$$

two sources of variable voltage are needed to represent x and z. These are fed into input resistances R_1 and R_2 as illustrated in Fig. 3*b*. If the feedback resistance R_f = 15,000 ohms; R_1 = 3000 ohms, and R_2 = 5000 ohms, the output voltage $= y = -(5x + 3z)$.

Integration is carried out by replacing the feedback resistor by a condenser. To perform the operation

$$y = \int 5x\, dt \tag{11}$$

the voltage representing x is fed into the amplifier

through a 200,000 ohm resistor. If a 1 mfd condenser is used in the feedback loop, the output voltage is

$$y = -\frac{1}{(0.2)(1)}\int x\,dt = -\int 5x\,dt$$

Differentiation may be performed by using a condenser as an input impedance with a resistor in the feed back loop. This process is usually avoided where possible, since noise and stray signals in the input voltage tend to be accentuated upon differentiation.

Problems of greater complexity may be handled by a combination of these methods. Thus, for a simple differential equation of the form

$$Dx + 5x = F \tag{12}$$

where x = the time dependent variable; $D = d/dt$; F = external excitation.
the equation is solved for Dx and integrated to obtain

$$x = \int (-5x + F)\,dt \tag{13}$$

This equation states that the variable x will be obtained if $(-5x + F)$ is integrated with respect to time. The diagram for this problem is shown in Fig. 3*d*. Here, the voltage $-x$ is fed into the amplifier through a 200,000 ohm resistor, the voltage corresponding to F is fed into the same amplifier through a 1,000,000 ohm resistor, and the feedback impedance is a 1 mfd condenser, the output voltage will be

$$-x = -\left[\frac{1}{(0.2)(1)}\int -x\,dt + \frac{1}{(1)(1)}\int F\,dt\right]$$

$$= -\int (-5x + F)\,dt$$

This type of problem may also be solved by direct simulation. Thus, solving Equation 12 for x gives

$$x = \frac{F}{5 + D} = \frac{0.2F}{1 + 0.2D} \tag{14}$$

Since the impedance of a 1 mfd condenser in parallel with a 200,000 ohm resistor is

$$Z = \frac{R}{1 + RCD} = \frac{200{,}000}{1 + 0.2D} \tag{15}$$

the use of such a network as the feedback impedance in conjunction with an input resistance of 1,000,000 ohms for the excitation simulates the problem as shown in Fig. 3*e*.

Nonlinear Applications: Complete coverage of the various methods in current use for handling nonlinear problems on the analog simulator is beyond the scope of this short discussion. The two major methods of attacking such probleme are *linearizing*, or use of *function generators* or *multipliers*.

The process of linearizing an equation involves the replacing of a nonlinear variable by an approximate linear expression. Thus for a flow problem, where the fluid flowing at any time is given by the expression

$$q = Ca\,(2gH)^{1/2} \tag{16}$$

the head H to the one-half power represents the nonlinear term. By using a reference head H_m and a deviation head h, such that

$$H = H_m + h = H_m\left(1 + \frac{h}{H_m}\right) \tag{17}$$

the expression for $H^{1/2}$ may be expanded by means of the binomial theorem to give

$$H^{1/2} = H_m\left(1 + \frac{h}{2H_m}\right) \tag{18}$$

This is a valid linear expression as long as the higher terms in the expansion may be disregarded. Similar methods and assumptions are made in other cases, such as the replacement of Coulomb friction by viscous friction or the approximation of a nonlinear spring characteristic by a straight-line force-deflection curve.

The use of function generators or multipliers involves the use of auxiliary equipment which will accept two voltages, x_1 and x_2 and produce an output voltage proportional to the product of x_1x_2. If the output is directly proportional to the product of the input voltages, the device is a multiplier. If the output is proportional to $x_1\,f(x_2)$, the device is a function generator. Usually, the same device may be made to serve as either a function generator or a multiplier.

Fig. 4 shows diagrammatically the basic form of a simple multiplier or function generator. The voltage $+x_1$ and $-x_1$ is applied to a potentiometer. The voltage x_2 is applied to a servomotor which moves the potentiometer arm in direct proportion to the voltage x_2. Hence the voltage from the wiper arm to ground is proportional to the product x_1x_2. This last statement assumes that the potentiometer is linear, in which case the device is a

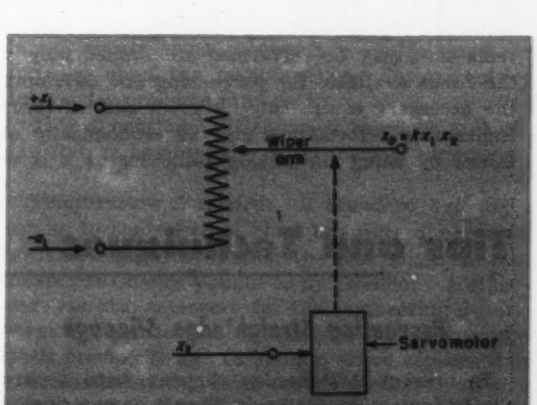

Fig. 4 — Schematic of typical servo-driven multiplier or function generator.

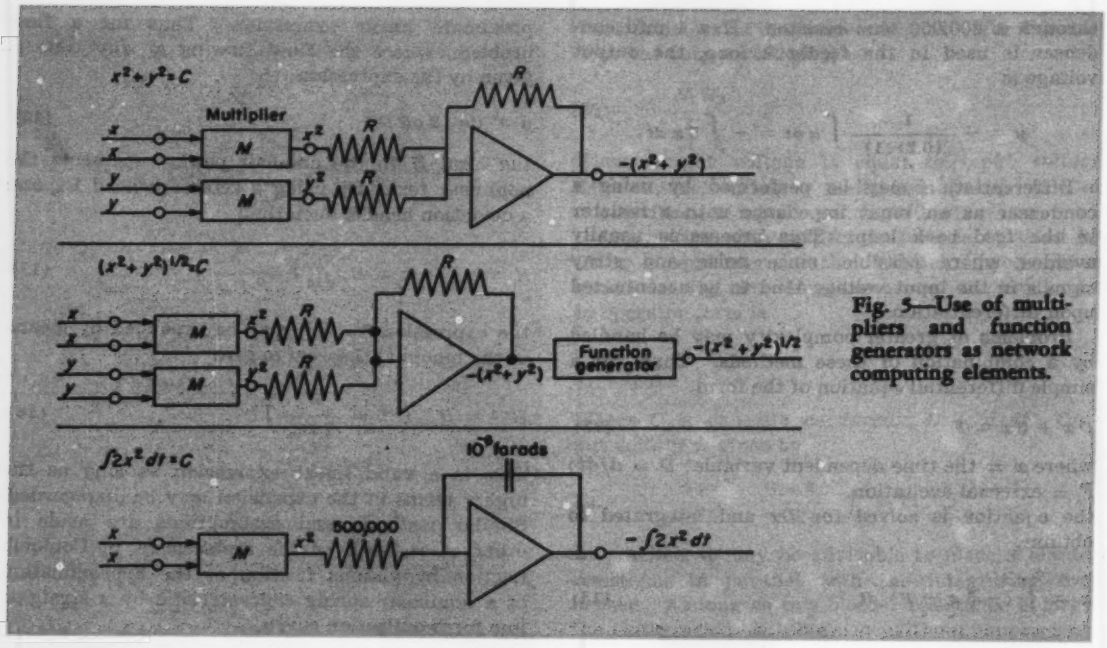

Fig. 5—Use of multipliers and function generators as network computing elements.

multiplier. If the potentiometer is wound so that the resistance change with wiper arm position is nonlinear, the output voltage will be proportional to $x_1\ f(x_2)$ and the device is a function generator. When windings on the potentiometer are suitably contoured, the function generator may be made to yield the square, the square root, or any other given function.

These statements should not be interpreted to mean that the system shown in Fig 4 is the only means of multiplication or function generation. There are many excellent devices on the market which will multiply two or more voltages or generate predetermined functions. The operating methods of these devices are varied and too numerous for discussion here.

Fig. 5 shows some of the operations that may be performed with multipliers and function generators. In general, the complexity of the operations that may be performed are limited only by the funds available for purchasing and developing the necessary equipment. A great deal of useful engineering information may be economically obtained by using the analog simulator as a linear instrument through judicious linearizing of the system parameters. Function generators and multipliers will greatly enhance the value of the simulator by permitting more exact investigation of nonlinear systems.

Excitation and Recording: For initial economical studies of systems on the analog simulator, sources of direct current voltage for step and pulse excitation and an audio frequency oscillator for harmonic excitation are sufficient. For more advanced work, some means of generating arbitrary voltage inputs may be desirable. These may range from simple motor-driven nonlinear resistances to expensive photo-tube cathode ray tube follower devices which are on the market.

For recording input and output voltages, a good cathode ray oscilloscope will suffice for frequency response studies. It is often convenient to have some type of direct recording oscillograph when transient responses to pulses and step inputs are studied, and there are recorders on the market which will plot directly the output of a simulator as a function of time or frequency.

Tips and Techniques

Preventing Straightedge Slippage

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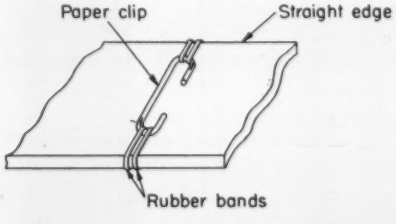

Specifying Manufacturing Temperatures

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1

Temperature control during manufacturing processes is necessary to maintain a high degree of precision. This article outlines a method of setting up standards for specifying temperatures at which machine parts should be manufactured, according to size and material, to obtain required tolerances.

By John R. Saul, *Producibility Engineer*
Chance Vought Aircraft Inc., Dallas, Texas

VARIATION in dimensions of metals due to temperature changes is an increasingly critical problem where close tolerances are required. Some industries, such as precision instrument manufacturers, have solved this problem by controlling the production environment. Another example is in the manufacture of airframes, where variations in length previously considered negligible have become magnified by the precision now required in control systems, and greater manufacturing temperature control is necessary.

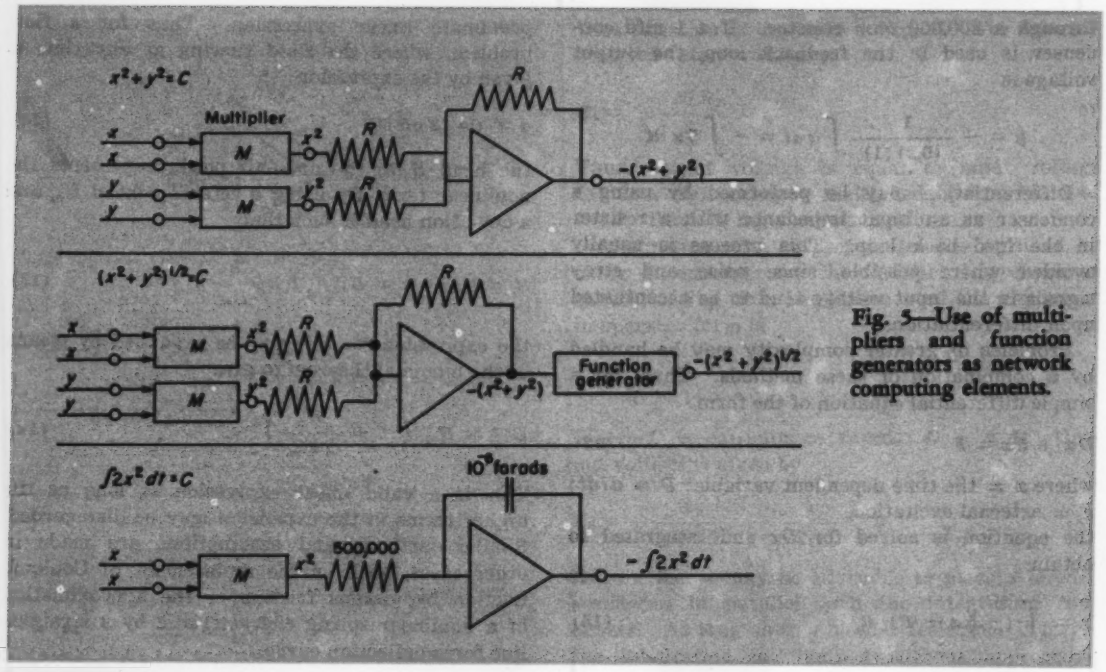
Interchangeability of both complete units and components is necessary to fulfill the requirements of package installations. Use of oversize holes is, of course, obviated by the need for precision. Linkage attachment points must have as little play as economically practical. Sizing holes on installation is contrary to the interchangeability concept. The only alternative then is to hold the controlling dimension accurately.

While designing the F8U "Crusader," Chance Vought Aircraft found that certain control linkages could be adversely affected by atmospheric temperatures encountered during manufacture and installation of the parts. For example, an aluminum link with hole centerline distance of 25 in. could be manufactured one time at 60 F and another time at 100 F. If these were installed as a pair, there would be a dimensional difference of 0.013-in. due to thermal expansion alone. If the total tolerance that can be absorbed in the links is less than 0.013-in., obviously some temperature control must be imposed upon the manufacturing department or the vendor producing the part.

This dimensional difference is based on a checking fixture having little or no thermal expansion.

Temperature Standard: A standard had to be set up to control these close tolerance dimensions, without regard to whether the part might be fabricated at Chance Vought or by a vendor. A standard was also necessary for the engineering department in order to place all designs of this type on a basis previously agreed upon by those concerned in the manufacturing, and design sections. It was also desirable in order to preclude errors and reduce the time required to complete a drawing by eliminating computations.

As in most standards, some compromise was necessary in order to adapt it to general usage.



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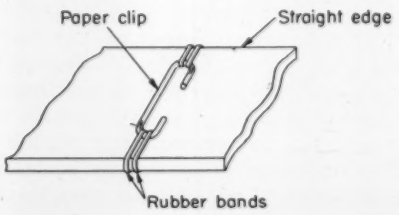

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Temperature Standard: A standard had to be set up to control these close tolerance dimensions, without regard to whether the part might be fabricated at Chance Vought or by a vendor. A standard was also necessary for the engineering department in order to place all designs of this type on a basis previously agreed upon by those concerned in the manufacturing, and design sections. It was also desirable in order to preclude errors and reduce the time required to complete a drawing by eliminating computations.

As in most standards, some compromise was necessary in order to adapt it to general usage.

The bases decided upon had to be tailored to the application. For control system dimensions at Chance Vought, these bases were:

1. Variations from atmospheric temperature conditions during manufacture shall produce no greater variations than one quarter of the total dimensional tolerance.
2. Normal manufacturing temperatures are in the range of 60 to 100 F.
3. Variations of a basic type of material would not have enough differences in coefficient of thermal expansion to produce a measured effect (7075, 2024, 6061 aluminum, etc.).
4. When a combination of different materials are used in one link, the link shall be considered to be composed entirely of the material having the greatest effect.
5. A table shall be set up with 10-in. increments. Borderline cases may be determined individually.

A possible expansion no greater than one quarter of the total tolerance on the dimension considered could put the dimension beyond acceptable limits. Adjustment can be made for this condition, however, in two ways. One method is to divide the total acceptable tolerance by 1.25 and specify this new tolerance on the drawing. The other method is to compensate for this added variation in table form by showing a dimensional tolerance which includes possible thermal variations.

Temperature Control Table: In computing Table 1, the longest length of each 10-in. increment is used. Combining this factor with the probabilities incurred in dimensional and thermal variations lowers the probability that all of these factors would work simultaneously to make the part unacceptable when it is produced according to the drawing. The table therefore, makes no compensations, nor are any made by the designer.

Temperature control available in the general area of Chance Vought and in most air-conditioned factories is 75 $\pm$5 F. A special machine shop room maintains a temperature of 70 $\pm$2 F, and this amount of control is also available at some vendor companies. Every effort should be made to avoid designs requiring production of parts within the 68 to 72 F levels, however.

Chance Vought uses the following general note on drawings requiring temperature control during manufacture: "This dimension to be manufactured and inspected at —— F. Twenty-four (24) hours minimum soaking time required prior to machining and inspection." This note is filled in per Table 1 with either 70 $\pm$2 F or 75 $\pm$5 F. On the drawing, a local note at the dimension concerned calls attention to the general note.

Coefficients of thermal expansion (K factors) used in computing the table are: aluminum, K = 0.0000130; magnesium, K = 0.0000144; and steel, K = 0.0000062.

Returning to the original example of an aluminum link with a centerline hole dimension of 25 in., the table shows that the closest tolerance applicable is $\pm$0.003-in., using a manufacturing temperature limit of 70 $\pm$2 F. If it is unnecessary to hold the dimension this close, the next level, of course, would be used, which is $\pm$0.005-in. From the table, the 70 $\pm$2 F, however, is still required.

Table 1—Temperature Limits for Production of Critical Dimensions*

Tolerance (in.)	Temperature (F) for Length of 0–9.99 in.	10.00–19.99 in.	20.00–29.99 in.	30.00–39.99 in.
For magnesium alloys				
$\pm$0.001	†	†	†	†
$\pm$0.002	70$\pm$2	70$\pm$2	†	†
$\pm$0.003	75$\pm$5	70$\pm$2	†	†
$\pm$0.005	75$\pm$5	70$\pm$2	70$\pm$2	70$\pm$2
For aluminum alloys				
$\pm$0.001	70$\pm$2	†	†	†
$\pm$0.002	70$\pm$2	70$\pm$2	†	†
$\pm$0.003	75$\pm$5	70$\pm$2	70$\pm$2	†
$\pm$0.005	75$\pm$5	75$\pm$5	70$\pm$2	70$\pm$2
For steel				
$\pm$0.001	70$\pm$2	70$\pm$2	†	†
$\pm$0.002	75$\pm$5	75$\pm$5	70$\pm$2	70$\pm$2
$\pm$0.003	75$\pm$5	75$\pm$5	70$\pm$2	70$\pm$2
$\pm$0.005	75$\pm$5	75$\pm$5	75$\pm$5	75$\pm$5

* From *Engineering Design Manual* of Chance Vought Aircraft. † This tolerance is impractical at this length.

Should a tolerance of $\pm$0.003-in. be unacceptable, it is possible to compute what tolerance can be held. Substituting in the formula $(\Delta L) = KL(\Delta T)$ gives $(\Delta L) = 0.000013 \times 25.000 \times 4$, where (ΔL) = variation in length, in.; K = coefficient of thermal expansion; L = length, in.; and (ΔT) = variation in temperature, F. This shows a possible variation of 0.0013-in. due to thermal effects. The basic decision that these effects shall be no greater than one quarter of the total dimensional tolerance permits, then, a total tolerance of 0.0052 or $\pm$0.0026-in. The closest three-decimal standard, therefore, still remains at $\pm$0.003-in., and a different design or material must be considered.

A simple, nomographic method for determining

Vibration Power

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Westinghouse Electric Corp.
Baltimore, Md.

Based on a power or energy concept, the method proposed in this article is useful for analyzing all vibration problems. It is particularly suitable for studying the effects of vibration on electrical noise. But it has advantages for every type of equipment vibration study. The power or energy spectrum is far steadier than acceleration (G) or excursion spectra; "destructability" of vibration is more accurately gaged; and best of all, usable, comparable records can be kept for use in future designs.

STRUCTURES must often be designed to withstand vibration over a wide frequency range. Particularly in military vehicles and aircraft, input vibration to the equipment can be over a broad spectrum.

One conventional method for studying sensitivity of such equipment is to plot some parameter—amplification ratio, acceleration ratio, transmissibility (through isolators), etc.—against frequency. Values may be theoretical, such as derived from a mathematical analysis. Or they may be obtained by shaking the equipment on a vibrator at the desired frequencies.

The method outlined in this article is basically the same—except that energy or power is the second basic parameter. A vibration-power chart, Fig. 1, helps in analysis. The method is particularly worthwhile when the experimental approach is used, and it is well suited for analysis of electronics equipment to determine effect of vibration on electrical noise.

Advantages of the method are many. The excitation spectrum expressed in terms of power or energy is far steadier than the often-used input-acceleration (G) spectrum. Records are easily understood and, furthermore, are broad enough to be applied to new designs still on the drafting boards. And vibration power is a more realistic parameter than G loads to use when studying such phenomena as bottoming of isolators and effects of structure natural frequency on amplification ratio or transmissibility.

In design of electronics equipment, particularly, the vibration-power concept can be a big help. Electrical "noise" is a function of vibration power and energy, not of G load or excursion, so studies in terms of power can be directly related to design of supporting equipment.

Reasons why the excitation spectrum expressed in terms of vibrations power is far steadier than the spectrum in terms of acceleration are clearly shown in WADC *Technical Report* 53-479. Stress in a structure may bear an exact relationship to acceleration. But in actual every-day experience the relationship between stress caused by vibration acceleration and the resulting strain appears to be an empirical relationship. The vibrational modulus of elasticity increases with increase in frequency—and differently in different materials—even though maximum vibration acceleration is held constant. Thus, since modulus of elasticity equals stress over strain, the strain fluctuates with frequency.

Vibration "destructability" is essentially measured by strain on the component or structure. It follows that acceleration is a variable and generally unpredictable measure of this "destructability". A far more adequate measure is energy absorption or energy transmissibility, particularly if the designer wants to keep usable comparable records of past designs and improvements.

Basic Formulas: In the development of the basic nomograph, Fig. 1, several simplifying assumptions have been made. These are: (1) that

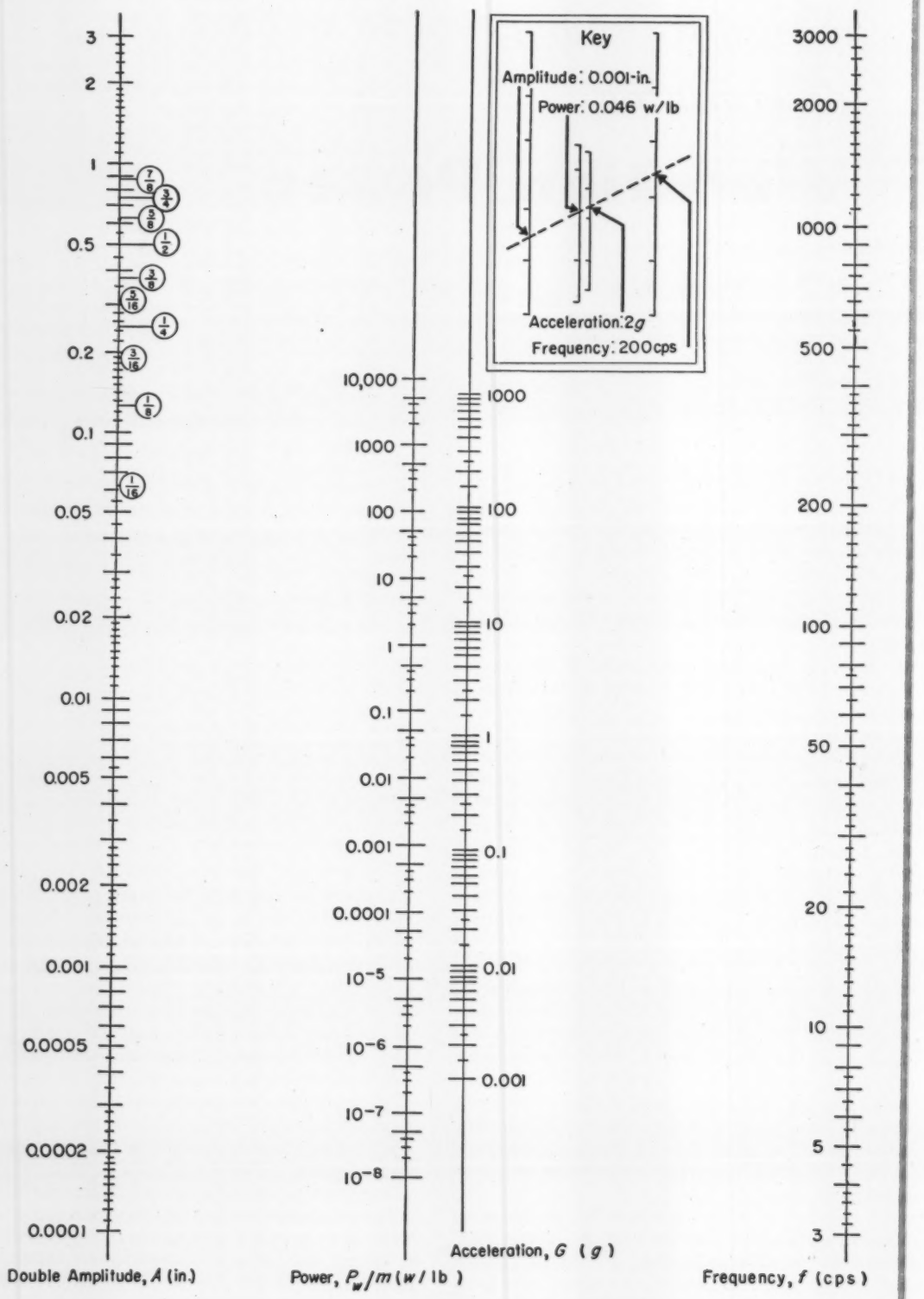

Fig. 1—Nomograph for evaluating vibration power.

the vibration is simple harmonic motion—no assumption at all for most vibration test equipment, and (2) the maximum acceleration, G, acts over the full vibration cycle. This second assumption makes no difference in accuracy of the results, providing all data are compared on the same basis.

Power developed in one complete cycle of vibration is

$$P_i = FAf = mGAf \qquad (1)$$

where P_i = power, lb-in. per sec; F = force, lb; A = vibration amplitude (double), in.; f = frequency, cps; m = mass, lb/g; and G = maximum acceleration, g. Acceleration of gravity, g = 386 in. per sec^2.

Maximum acceleration during harmonic motion is

$$G = \frac{\omega^2 A}{2}\left(\frac{1}{386}\right) = \frac{2\pi^2}{386} f^2 A$$

$$= 0.05114\, f^2 A \qquad (2)$$

where ω = circular frequency, radians per sec.

Combining Equations 1 and 2 and dividing by the mass, the expression for power becomes

$$\frac{P_i}{m} = 0.05114\, A^2 f^3 \qquad (3)$$

If power is expressed in watts (8.85 w = 1 lb-in. per sec), Equation 3 becomes

$$\frac{P_w}{m} = 0.00578\, A^2 f^3 \qquad (4)$$

where P_w = power, watts.

The power nomograph, Fig. 1, solves Equations 2 and 4, and also the function resulting when Equations 2 and 4 are combined. Any combination of A, f, P_w/m, or G, can be "inputted." In practice, of course, f and either A or G are usually the known factors; P_w/m is the unknown.

Since the power term, P_w/m, involves division by m, the results are independent of the weight of the equipment being tested or studied.

Typical Uses for the Vibration Power Concept: Energy solutions for structures under load are a combination of axial, bending, shear and torsional loads. A complete theoretical evaluation for all of these components is possible but very time-consuming.

An empirical but more positive method is to put the structure on a vibration table and shake it through the significant frequency range. Vibration-power values through this range are recorded, using the nomograph. The structure can be changed on the vibration table by stiffening and loosening members, and the vibration-power values again recorded through this frequency range. Thus, observations provide a record of vibration-power outputs of different structural configurations or conditions.

As an example, a bracket may hold an electronic tube capable of predetermined power absorption at

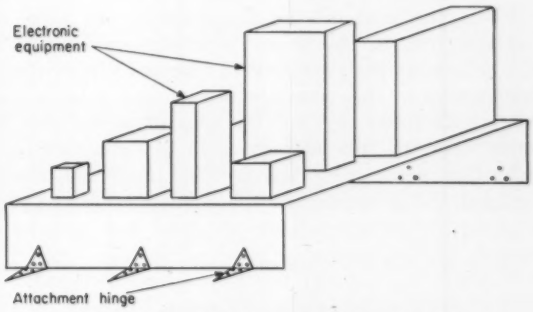

Fig. 2—Typical electronics chassis with hinged support to structure.

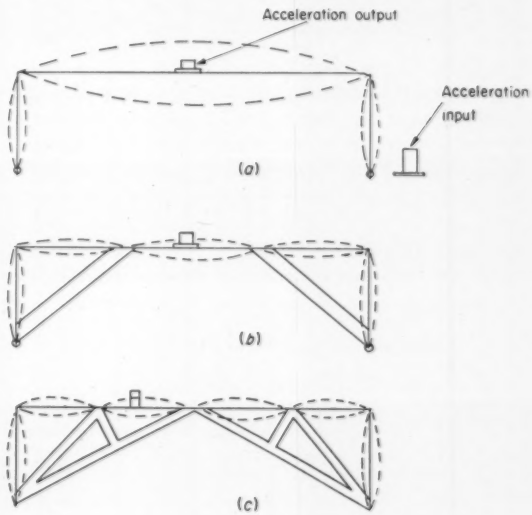

Fig. 3—Motion of electronics chassis in vertical plane. Fundamental response, *a*, is changed by adding stiffeners, *b* and *c*.

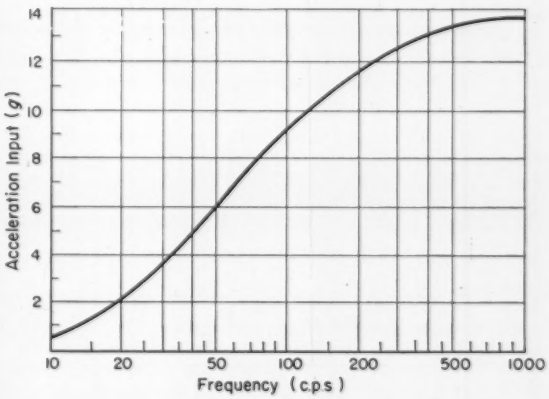

Fig. 4—Typical spectrum of acceleration (G) to meet vibration specifications.

various pertinent driving frequencies. An accelerometer can be placed on the bracket to measure *G*. Vibration-power values can be read from the nomograph. The microphonics of the tube will vary with frequency, but the amount of electrical noise that the tube will generate is a function of vibration power absorbed by the tube from the bracket. If a number of tubes are placed on the bracket, the sensitive frequency band may be quite broad. By stiffening and loosening this bracket the designer can determine the amount of vibration power getting through to the tubes. He can then set up parameters of design for the bracket that can apply to future designs by comparison with the predetermined power-absorption capability of the individual tube types employed.

A further example is in the use of vibration isolators. Published data on most commercial isolators show transmissibilities of particular isolators through certain frequency ranges. For a given specification, this presentation is usually adequate. But today, with more and more severe loading conditions coming into play, such things as the mount bottoming due to vibration superimposed on steady state, and *G* values above the specification range, can make this transmissibility curve meaningless.

A better criterion for the designer would be the energy-absorption qualities of the isolator. Equipment cannot be tested at two frequencies simultaneously, but field data can record energy saturation of the mount. In this way a power versus frequency curve can spell out for the designer how much in the way of loads at different frequencies the isolator can absorb. Records of this type of data, compiled by using the nomograph, offer the designer another tool to insure more reliable and less expensive equipment.

Design Procedure for Electronics Equipment: The engineer should be able to predict ahead of time the vibration level of an electronic chassis so he can cope with this vibration in the circuit design. Vibration motion on top of the chassis moves the electronic components so that they do not respond properly to their electrical stimulus. The result could be jitter on an oscillograph; it may be chattering of relays; it could be a distortion in the magnitude of current or voltage caused by vibration motion.

For purposes of illustration, a typical electronic chassis is shown in Fig. 2. This chassis is attached by hinges to a support structure, such as an airplane.

A common procedure for design of this elec-

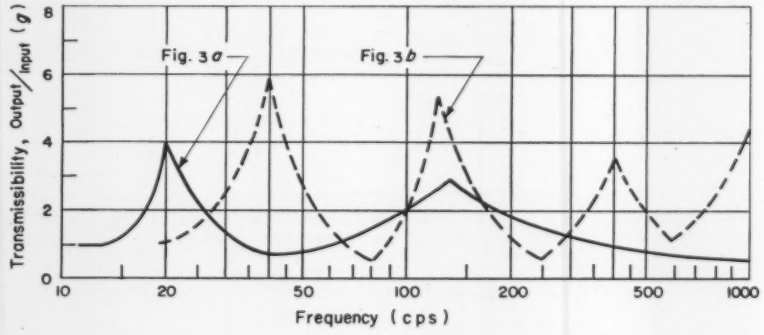

Fig. 5—Transmissibility of chassis shown in Figs. 3*a* and *b* when subjected to the input acceleration of Fig. 4.

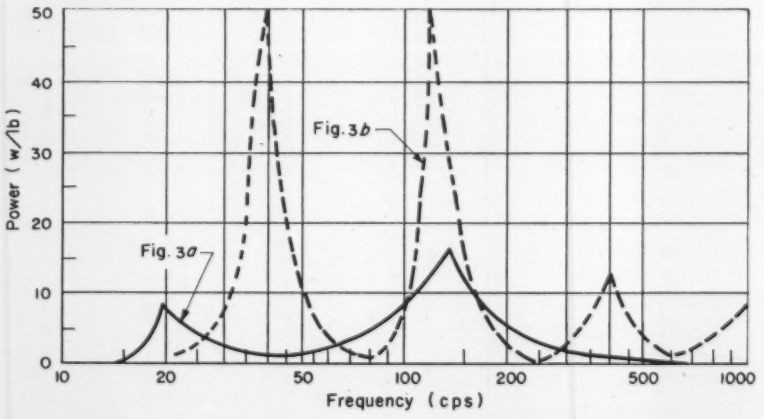

Fig. 6—Actual power transmitted to the electronics equipment of Figs. 3*a* and *b* when subjected to the input vibration of Fig. 4.

Table 1—Sequence of Designing an Electronics Package

1. The circuit diagram is worked out.
2. Size and weight of the equipment are determined.
3. Components are selected and arranged within the space and weight alloted. Cooling and other design problems are studied.
4. The chassis and structural system are arranged to withstand external loads.
5. A prototype model is made and subjected to the specified vibration. If structural failure results, the equipment is patched or isolated.

Present Method

6. With the electronic equipment operating, the prototype is placed on the vibration testing machine and subjected to vibration.
7. Actual response of the electronic equipment is read with the testing machine operating. Electrical noise values are noted, and critical noise frequencies recorded.
8. Immediate "fixes" are arranged: (1) parts may be stiffened or weakened to change the critical frequencies; (2) isolators may be placed under the entire chassis or critical components; (3) sensitive electronic equipment may be moved to noncritical locations on the chassis; and (4) sensitive electronic components may be replaced by more rugged components.

Proposed Method

6. A modified chassis is built, Fig. 3, with the same physical characteristics as the prototype. Typical weights, instead of actual equipment, are randomly distributed on the chassis. Accelerometers are placed on the chassis, and the chassis is tested across the specified vibration range.
7. Ratio of input to output acceleration values are recorded, and values are transformed to vibration power with the nomograph, Fig. 1.
8. Modifications are studied by rearranging weights, changing the chassis structure or materials, or adding vibration mounts.

9. The prototype is modified to incorporate changes and subjected to a last "check" test.

tronics equipment is reviewed in Table 1. A study of the technique under *Present Method* reveals several interesting points:

1. The technique is time-consuming. Testing machine time is at a premium, and so-called "quick fixes" may take weeks.

2. Since production schedules demand equipment immediately, temporary fixes get into the equipment. A more thorough change might be much better.

3. Thorough records are difficult to keep. Other engineers doing the same work cannot benefit from the quick fixes and juggling changes.

4. Balance is hard to achieve. Good dynamic design should consider all phases from components, to circuits, to chassis, to system.

5. The engineer has never defined his noise level. He just knows that a particular chassis will respond in such a way with such-and-such an input. He can never tell what effect the addition of, for example, a 10-lb transformer will have.

The following system, reviewed in Table 1, is proposed so that the engineer can have rational and simple parameters for use in chassis design. First, a modified chassis is built, Fig. 3*a*, similar to that of Fig. 2. The physical characteristics of this chassis are the same as the prototype, but weights are placed on top to provide a good random distribution of typical components on this chassis.

The input vibration specification is called out on Fig. 4. The chassis to be studied is placed on top of a testing-machine head. Outputs are recorded

Table 2—Comparison of Accelerations, Transmissibilities, and Power

Frequency	Input Accel.	Transmissibility		Output Acceleration		Output Power	
		Fig. 3*a*	Fig. 3*b*	Fig. 3*a*	Fig. 3*b*	Fig. 3*a*	Fig. 3*b*
(cps)	(*g*)			(*g*)	(*g*)	(w/lb)	(w/lb)
10	0.5	1.0	1.0	0.5	0.5	0.06	0.06
15	1.2	1.4	1.0	1.7	1.2	0.42	0.22
20	2.1	4	1.0	8.4	2.1	8.0	0.5
25	3.0	2.2	1.6	6.6	4.8	4.0	2.1
30	3.7	1.4	2.6	5.2	9.6	2.1	7.0
35	4.4	1.0	4.0	4.4	17.6	1.5	20.0
40	5.0	0.8	6.0	4.0	30.0	1.0	50.0
45	5.5	0.8	3.8	4.4	21.0	1.0	22.0
50	6.0	0.8	2.7	4.8	16.2	1.1	12.0
55	6.4	0.9	2.0	5.8	12.8	1.3	7.0
60	6.8	1.0	1.5	6.8	10.2	1.8	4.0
65	7.2	1.1	1.1	7.9	7.9	2.2	2.2
70	7.5	1.2	0.9	9.0	6.8	2.7	1.6
80	8.1	1.5	0.6	12.1	4.9	4.1	0.8
90	8.6	1.8	1.2	15.5	10.3	6.0	2.5
100	9.1	2.0	2.0	18.2	18.2	7.7	7.7
110	9.4	2.3	3.0	21.6	28.2	10.1	16.0
120	9.8	2.6	5.3	25.5	51.9	10.3	50.0
135	10.3	3.0	4.0	30.9	41.2	16.0	30.0
150	10.7	2.6	3.0	27.8	32.1	12.0	16.0
200	11.5	1.8	1.2	20.7	13.8	5.0	2.2
250	12.1	1.4	0.6	16.9	7.3	2.3	0.5
300	12.5	1.2	1.4	15.0	17.5	1.8	2.2
350	12.8	1.1	2.4	14.1	30.8	1.4	6.2
400	13.0	1.0	3.5	13.0	45.5	1.0	12.0
500	13.3	0.8	2.0	10.6	26.6	0.5	3.1
600	13.4	0.7	1.2	9.4	16.1	0.4	1.0
700	13.5	0.6	1.8	8.1	24.3	0.2	2.0
800	13.6	0.6	2.6	8.1	35.4	0.2	3.3
1000	13.7	0.5	4.5	6.9	61.6	0.1	8.0

on the chassis with an accelerometer, Fig. 3*a*. The ratio of output to input in *G* is calculated and recorded, Fig. 5.

A series of these curves can be drawn by changing the weights on the top of the chassis to simulate a random distribution of any combination of the total weight to be placed on the chassis. With a single accelerometer, a single value of acceleration at the point of maximum acceleration can be the only one recorded. A better method, however, is to put a number of accelerometers across the chassis and record either the peaks on all of them or to record a weighted average of the sum of the accelerations. In any event, the motion of the top of the chassis is defined as a certain magnification in *g*'s across the plate through a certain frequency range for a random distribution of weight on the top of the chassis.

The engineer is interested in electrical noise, which is a function of power rather than that of acceleration. Table 2 tabulates the specified maximum accelerations from Fig. 4. The transmissibilities of Fig. 5 and the outputs are calculated and listed by multiplying the input in *G* by the transmissibility.

The vibration chart, Fig. 1, is next used to get the power values. These power values are plotted on Fig. 6. This work summarizes the complete story of vibration on the chassis of Fig. 3*a*.

Next, the design engineer can study modifications to the chassis. Fig. 3*b* is a typical modification. The same procedure is followed with the new modification. Values are shown on Figs. 5 and 6, and in Table 2. On Fig. 5 it is hard to tell if the structural design modification has increased electrical noise appreciably, but Fig. 6 points out quite clearly the damaging effect of stiffening up the structure.

Many other modifications to design could be studied. Fig. 3*c* is another example of beefing-up that could be studied. A substitution could be made in the material used. A substitution could be made in the hinges. Support structures could be added to change the action of the chassis under load. Shock and vibration mounts can be placed under the structure and the power values plotted.

With isolators, the damaging effect of bottoming is far more severe from an electrical noise point of view than just tying down the structure. When the isolator bottoms, every element and mode of the basic chassis is excited, and some of them quite strongly. The vibration or power floods the entire chassis. The effect of steady state loads on top of vibration loads is also interesting. Again the mounts may bottom, causing a great deal of power and vibration to flood the entire chassis. The nomograph, Fig. 1, can also be used to evaluate isolators subject to this type of shock. Shock tests could also be performed and studied.

The vibration chart has many other uses, such as the plotting of design specifications. Basically, it affords a simple technique for evaluating power. This evaluation could become quite laborious if short-cut methods were not employed.

Strengthening Metal Stampings

DESIGN of metal stampings is usually determined by functional requirements and personal judgment and experience. Strength of stampings is ordinarily not calculated but arrived at by tests of sample parts before production actually begins. At times the tests establish a need for reinforcement of the stamping.

One of the best and least expensive solutions in such cases is flanging, preferably of both sides of the stamping to form a channel-type stamping. Purpose of this discussion is to point up the increased strength obtainable by this method.

The expression for deflection, *f*, of a beam supported at one end and loaded at the other is

$$f = \frac{Pl^3}{3EI}$$

where P = load, lb; l = free length of beam, in.; E = modulus of elasticity, psi, and I = moment of inertia, in.^{4} This shows that deflection of a component of given length, of a certain material, with a given load varies inversely with moment of inertia. Moment of inertia depends only upon thickness and shape of the cross section. To illustrate the increased stiffness obtainable by flanging and relatively small amount of additional material required, values of moment of inertia for a 2-in. wide, 0.1-in. thick strip as well as for some 2-in. wide, 0.1-in. thick section channels of various depths have been computed, Table 1.—FEDERICO STRASSER, Santiago, Chile.

Table 1—Flat and Channel Section Comparison

Total Depth of Piece (in.)	Area of Cross Section (sq in.)	Area Increase (%)	Moment of Inertia Increase (%)
0.1	0.20	0	0
0.3	0.24	20	660
0.5	0.28	40	3 700
0.7	0.32	60	9 700
0.9	0.36	80	16 660
1.1	0.40	100	30 000

Tips and Techniques

Cam Locating Hole

In addition to the usual keyway for providing resistance to rotation on a shaft, a drilled and reamed hole in a flat plate cam has proved to be very useful for locating the cam during manufacture, testing and inspection.—CLINT MCLAUGHLIN, *New York, N. Y.*

DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY (*Fifth of a Series*)

Basic recommendations for designing

Maintenance Accesses in Electronic Equipment

Accesses provide a technician with a convenient means for entering electronic equipment to perform maintenance tasks without removing a large cover or opening fittings. Obviously, accesses should be designed to make it easy to enter and work on equipment. Design procedures and recommendations on location, shape, size, methods of fastening, and labeling and coding of accesses are given here.

By John D. Folley Jr. and James W. Altman

Research Scientists
American Institute for Research
Pittsburgh

IF MAINTENANCE accesses of the proper shape and size are not provided in electronic equipment or if these accesses are difficult to reach or use, it is likely that the maintenance tasks performed through these accesses will not be done as specified. Therefore, all maintenance procedures must be studied carefully and systematically to determine needs and uses for accesses.

Basic Design Procedure: To design an access, list each part of the equipment to be reached through the access and the operations a technician will likely perform on each part using that access. Then design the access to make those operations as simple as possible. Only enough data on the parts of electronic equipment to be reached through a given access and the operations to be performed on them should be listed to suggest the design features of the access. For example, one part of the equipment and the operation to be performed on it might be "Lubricate turret suspension bearing." This statement should provide enough detail to permit the designer to think of the steps a technician might go through to perform this lubrication so that the access can be designed to facilitate these steps. Remember that accesses include not only entrance doors, but also include electrical connectors, lubrication fittings, pneumatic fittings, hydraulic fittings, and inspection windows.

Openings for Physical Accesses: Use a hinged door, if possible, where physical access is required instead of a cover plate held in place by screws or other fasteners. If lack of available space for opening the access prevents use of a hinged opening, a cover plate with captive quick-opening fasteners can be employed.

If a hinged access or quick-opening fasteners will not meet stress, pressurization, or safety re-

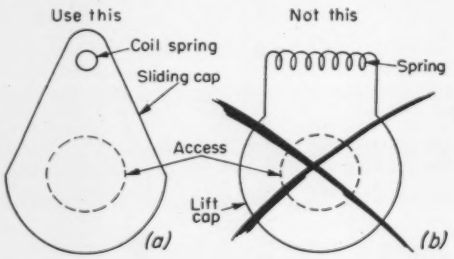

Fig. 1—Spring-loaded caps to keep dirt and moisture out of accesses. The sliding design, *a*, is preferable to the lift cap in *b*.

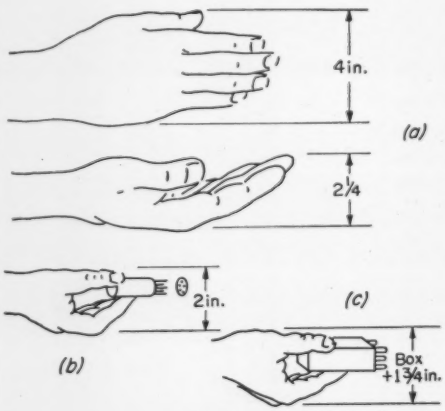

Fig. 2—Suggested minimum dimensions for accesses to accommodate one empty hand held flat, *a;* to permit inserting one hand up to the center knuckles when holding a miniature tube, *b;* and to allow passage of one hand holding a rectangular-shaped part, *c*.

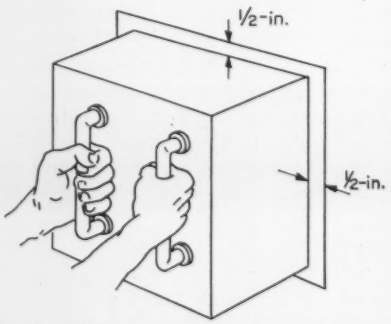

Fig. 3 — Aperture with a ½-in. clearance which is recommended for inserting with ease an electronic assembly by handles. Recommended clearance is based on experiments conducted using an 8 by 8 by 8-in. box that weighed 24 lb.

quirements, use the minimum number of the largest screws consistent with the stress requirements.

Accesses for Visual Inspection: It is preferable to design an opening with no cover unless this is likely to degrade system performance. However, if dirt, moisture, or other foreign materials are a problem, install a plastic window.

A break-resistant glass window should be used if physical wear or contact with solvents will cause optical deterioration of a plastic material. A quick-opening metal cover may be necessary if glass will not meet stress requirements.

Accesses for Servicing: An access designed for tools, test leads, and service equipment should be an opening with no cover unless this is likely to degrade system performance. However, if dirt, moisture, or other foreign materials are a problem, use a spring-loaded cap. If a spring-loaded cap is used, a sliding design, Fig. 1*a*, would be preferable to a lift cap, Fig. 1*b*. The latter design tends to break off more easily. If a cap will not meet stress requirements, it may be necessary to design a quick-opening cover plate.

Safety Design: Provide edges of accesses with internal fillets or with rubber, fiber, or plastic protection if they might otherwise injure technicians' hands or arms.

Provide safety interlocks on accesses that lead to equipment with high voltages. If the technician may need to work on the equipment with the circuit energized, provide a "cheater" switch that automatically resets when the access is closed.

Provide screwdriver guides to adjustment points that must be operated near high voltages.

Shape of Accesses: Make access doors whatever shape is necessary to permit passage of components and implements that must pass through. Access openings need not necessarily be a symmetrical shape like a square or a circle. If, for example, structural members in units prevent designing a symmetrically shaped access large enough for the function it must serve, make the access whatever shape is needed.

Labeling and Coding: Each access should be labeled with a number, letter, or other symbol designation assigned only to that access so each one can be clearly named in job instructions.

Where tubes or plugs have to be inserted through small accesses, an external indication of the position for pin insertion should be provided; for example, matching stripes or dots on tube or plug top and on the cabinet.

Label each access with the nomenclature for items accessible through it, for example, "CMS Adjust," or "Dynamotor Brush Access," or "Antenna Drive Lubrication." Each access should also be labeled with the nomenclature for auxiliary equipment to be used at it. For example, labels could read: "Antenna Drive Lubrication," or

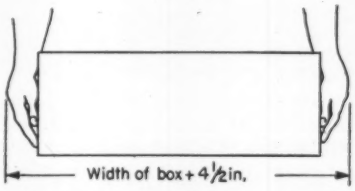

Fig. 4—Minimum opening for a rectangular unit wider than 15 in. grasped by the sides with two hands.

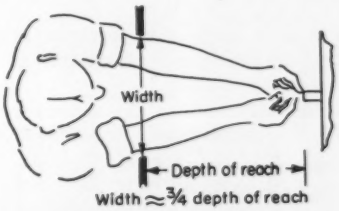

Fig. 5 — Width of an access for both arms should be about ¾ the depth of reach.

"Grease Gun 7208," or "Grease MIL-27-8694." Indicate under each access the recommended periods for accomplishing operations either in calendar time or operating time. If it is not feasible to present any of this material on or near the access, it should be presented in job instructions and identified by the symbol designation labeled on the access.

Location of Accesses: Location of accesses for line maintenance should be dictated by the way in which units are installed. Determine which faces of the unit will be accessible in the normal installation and place accesses on one of these faces. All accesses, displays, controls, cables, etc., should be put on the same face of a unit whenever possible. It is usually easier to keep only one face readily accessible in an installation than it is several faces.

Place access openings to permit maximum convenience in performing job procedures. Determine what the technician will have to do through a given access and place the access to accommodate that operation.

Size of Accesses: If equipment components must pass through an access, the size of the access must be large enough for the component plus the technician's hand and/or whatever tool is to be used to handle the components.

The suggestions for minimum access sizes discussed here are based mainly upon very informal measurements taken by project staff members on one another at the American Institute for Research. Some recommendations here are based upon a systematic collection of data on a small sample of subjects performing certain tasks, and others are extrapolated from carefully collected and analyzed anthropometric data.* All dimensions presented are offered only as useful approximations. Where the extrapolation from our measurements or from the anthropometric data may be somewhat tenuous, an attempt was made to err on the safe side by adding a margin of safety judged by the authors to be adequate. These measurements should provide enough space for 95 per cent of the technicians.

One-Hand Accesses: For a rectangular opening the approximate minimum dimensions required for inserting an empty hand held flat are 2¼ by 4 in., Fig. 2*a*. The smallest square hole through which an empty hand can be inserted is 3½ by 3½ in.

The smallest square hole through which a miniature vacuum tube held with the thumb and first two fingers may be inserted up to the center knuckle of the middle finger is 2 by 2 in., Fig. 2*b*.

A hand holding a ⅛-in. shank diameter screwdriver with a 1-in. diameter handle requires an opening 3¾ by 3¾ in.

A hole 4 by 4 in. is required to insert a large vacuum tube (CRC 1625; base diameter, 1⅜ in.; height 4½ in. exclusive of pins and grid cap). To insert and tighten an AN plug with an outside diameter of 1⅞ in. also requires a 4 by 4-in. opening.

To insert a box or rectangular-shaped electronic assembly held in one hand, an access the width of the box plus 1¾ in. is recommended, Fig. 2*c*.

Two-Hand Accesses: If an object is heavy for the position in which it has to be handled or if an object is held while a tool is operated (for example, screw and screwdriver), the technician may need to insert two hands and two arms through the access. Make the access door big enough to allow this.

A clearance of ½-in. on each side is recommended for easily inserting a box or electronic assembly grasped by handles into an aperture. This recommendation is based on a test that was run using an 8 by 8 by 8-in. box that weighed 24 lb., Fig. 3.

To reach straight ahead into an opening a full arms length (to shoulders), the access should be 19½ in. wide.

Inserting to the shoulders a box without handles wider than 15 in. grasped by the side with two hands requires an opening the width of the box plus 4½ in., Fig. 4.

To reach through an access with both hands to a depth of 6 to 25 in. to perform a simple task, the width required for both arms can be approx-

*H. T. E. Hertzberg, G. S. Daniels and E. Churchill—"Anthropometry of Flying Personnel—1950," *WADC Technical Report* 52-321, Sept., 1954.

imated by making it ¾ the depth of reach, Fig. 5. The height of the opening for the hands should be about 4 in.

If the technician must be able to see what he is doing inside the equipment, the access must be large enough for the technician's hand(s) or arm(s) and still leave an adequate view of what he is doing, Fig. 6*a*. Sometimes one access door and one window may be called for, Fig. 6*b*. Determine what the technician will have to see by studying the operations he will have to perform through the access before deciding on the access size.

For some operations it may be better to place the access to the side instead of directly over the operation. For example, it may be better to place an access 3 or 4 in. to the side of a screw adjustment rather than directly above the screw. This allows for the length of the screwdriver between the screw and the technician's hand. Incidentally, if screwdriver adjustments must be made blind, screws should be aligned horizontally rather than edgewise so screwdriver will not fall out of slots.

Fastening Accesses: The means of opening and closing accesses is an important design consideration. Use fasteners or latches that require no tools and only one hand to operate. Make them large enough to grasp easily.

Use fasteners or latches requiring only a fraction of a turn or quick snap action in order to open or close.

Use captive fasteners. Fasteners that are not captive often become lost.

Use a few large screws instead of many small screws in access covers that must also serve as stress members insofar as this is compatible with stress requirements.

On hinged access doors place the hinge on the bottom or provide a prop so that the door will stay open without being hand-held if unfastened in a normal installation, Fig. 7.

Attaching Auxiliary Equipment: Connectors for auxiliary equipment should require no tools for their operation. If tools must be used, standard hand tools should be suitable for the technician to operate connectors.

Connectors for auxiliary equipment should operate in a fraction of a turn or with quick snap action.

BIBLIOGRAPHY

This article is the fifth in a co-ordinated series by John D. Folley Jr. and James W. Altman. Previous articles, and issues of MACHINE DESIGN in which they appeared are:

Designing Electronic Equipment for Maintainability ..... June 14, 1956
Units, Assemblies and Subassemblies .... June 28, 1956
Covers and Cases ..... July 12, 1956
Wiring, Cables and Connectors ..... July 26, 1956

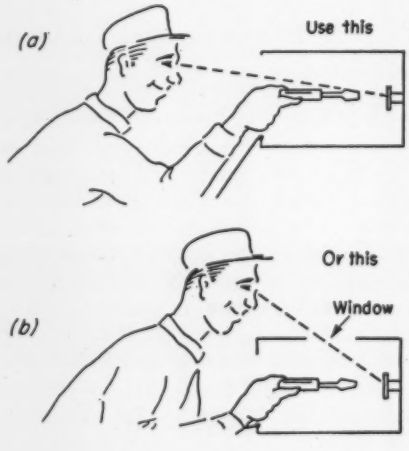

Fig. 6—Two methods of designing accesses to allow adequate view of work with hands in equipment. One large access door may be provided, *a*, or an access door and a window, *b*.

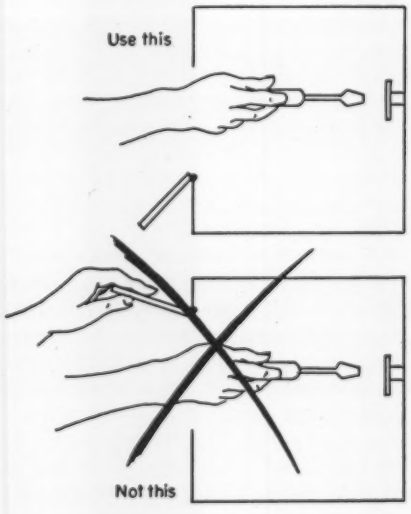

Fig. 7—Design hinged access doors to stay open without being hand held if unfastened.

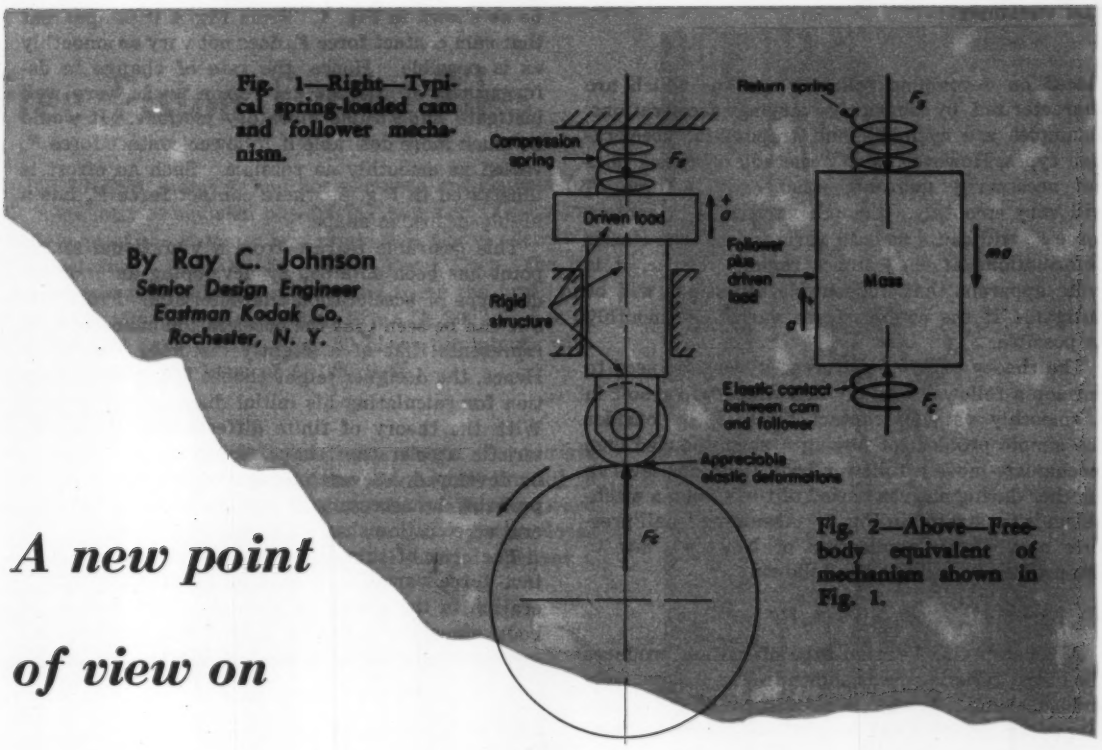

Fig. 1—Right—Typical spring-loaded cam and follower mechanism.

Fig. 2—Above—Free-body equivalent of mechanism shown in Fig. 1.

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A new point of view on

Minimizing Cam Vibrations

IN ACTUAL practice vibratory fluctuations are generally superposed on the theoretically desired follower body motion in high-speed cam mechanisms. Such vibratory motions are induced by external forces which cause sudden changes in elastic deformations. It is well known that sudden changes in elastic deformations initiate vibratory motion. One needs merely to consider a simple weight suspended from a spring and the effect which would result if the deformation of the spring were suddenly changed by means of a force applied suddenly to the end of the spring. Obviously, vibratory motion of the weight would occur at the natural frequency of the system.

For minimum vibratory motions in a cam mechanism, rigidity of structure in the linkage is essential. Unfortunately, the vicinity of contact between the follower roller and the cam surface is inherently a relatively elastic region. Appreciable elastic deformations often occur between cylindrical surfaces in contact.[1] Hence, an equivalent free-body diagram for a well designed spring-loaded follower body, Fig. 1, would be as shown in Fig. 2.

From basic mechanics, the motion of the follower body in Fig. 2 is influenced entirely by the characteristics of spring force F_s and cam contact force F_c.

Spring force F_s is directly proportional to the follower body displacement. For any of the commonly used follower body motions having smooth acceleration variations, the follower body displacement, and therefore spring force F_s, vary smoothly with respect to time. Hence, spring force F_s generally will not contribute directly to vibrational difficulties.

On the other hand cam contact force F_c often changes suddenly. Waviness of the cam surface due to machining errors would be one major source for this undesirable effect since such a waviness will cause acceleration fluctuations. Optimum choice of the cam angle interval for producing a master cam has been covered in a previous article which considers such acceleration fluctuations.[2] Sudden changes in contact force F_c are also caused by the characteristics of the primary acceleration component. Regardless of the cause, it can be stated that sudden changes in the follower contact force F_c result in sudden changes in elastic deformation at the contact region. Hence, undesirable vibratory motions are induced.

In the literature today, much emphasis has been

[1]References are tabulated at end of article.

placed on developing follower motions which are characterized by smoothly varying accelerations. Examples are cycloidal and trapezoidal acceleration types. However, such a method of attack does *not* necessarily guarantee that contact force F_c will vary smoothly. Smooth variations in contact force F_c will cause smooth variations of the elastic deformations at the contact region. Hence, it is quite apparent that undesirable vibrations will be mitigated if the contact force varies as smoothly as possible.

The theory of finite differences[2] may be used to develop a follower body motion which will result in a smoothly varying contact force, F_c. Consider the simple problem of having a spring-loaded cam mechanism move a follower body from one level to another during a given period of time. Such a mechanism is illustrated in Fig. 1. Assuming small pressure angles,[3] an application of Newton's law to the problem results in the following:

$$F_c = F_s + Ma$$

A constant-acceleration type of motion produces the characteristic curves shown in Fig. 3. Obviously sudden changes in cam contact force F_c exist, and vibrational difficulties might well be expected. On the other hand, if a motion is selected or developed such that a smoothly varying primary acceleration exists, the characteristic curves might be as shown in Fig. 4. From Fig. 4 it is apparent that cam contact force F_c does not vary as smoothly as is possible. Hence, the rate of change in deformations at the contact region might very well instigate undesirable vibratory motions. It would be much more desirable if follower contact force F_c varied as smoothly as possible. Such an effort is illustrated in Fig. 5, where contact force F_c has a highly desirable shape.

This desirable feature from a vibrational standpoint has been obtained by developing an unorthodox type of acceleration characteristic. From Fig. 5 it can be seen that the acceleration characteristic represents that of a slightly distorted sine wave. Hence, the designer might choose the cycloidal motion for calculating his initial displacement values. With the theory of finite differences, the characteristic acceleration shape shown in Fig. 5 could be developed. Several sequential traverses[2] would probably be necessary in order to develop the general acceleration shape of Fig. 5.

The crux of this discussion is that the cam contact force variation should be of primary consideration in the design of the motion for a follower body since the resulting elastic deformations are generally the actual causes of vibratory motions.

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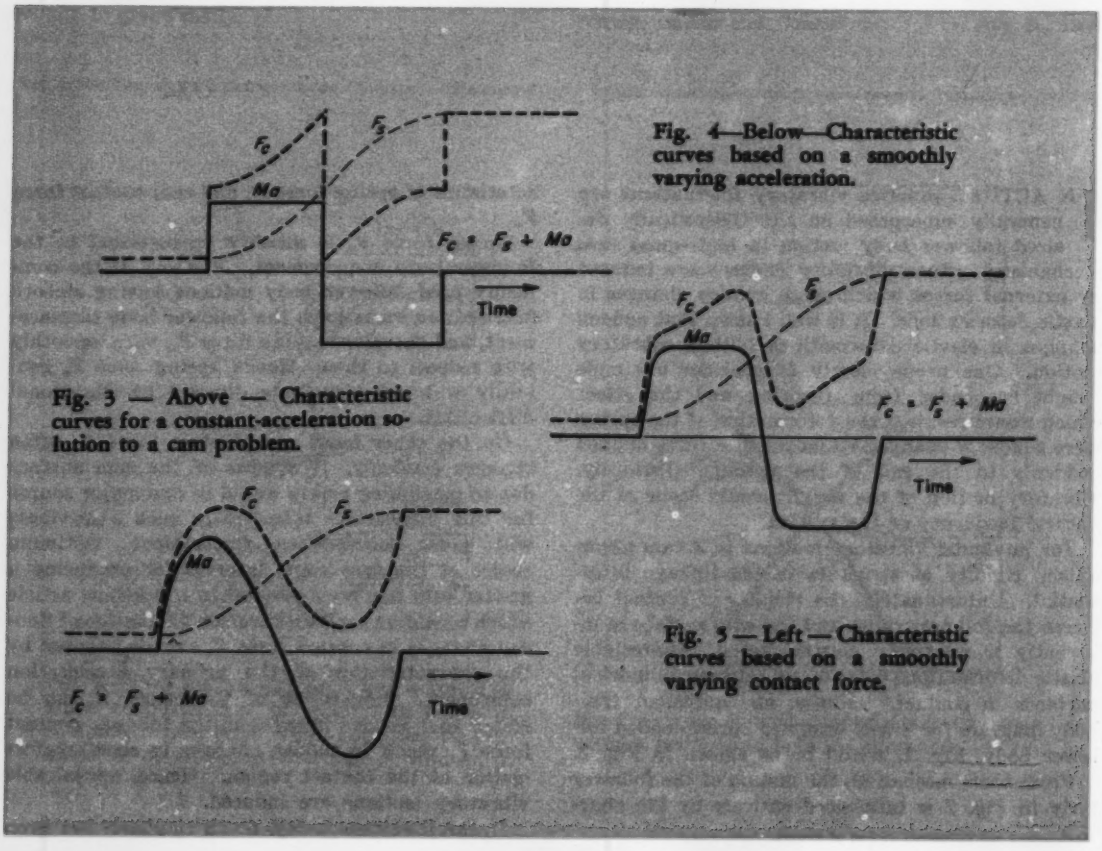


Fig. 3 — Above — Characteristic curves for a constant-acceleration solution to a cam problem.

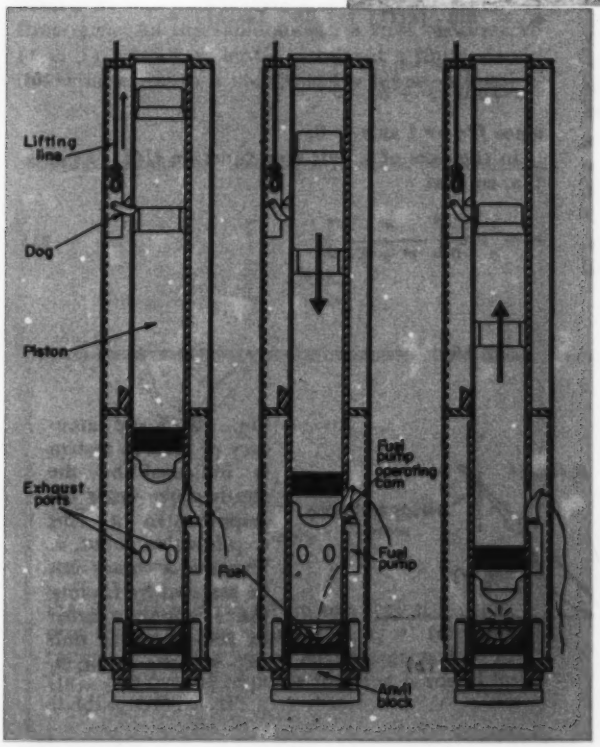
Fig. 4—Below—Characteristic curves based on a smoothly varying acceleration.

Fig. 5 — Left — Characteristic curves based on a smoothly varying contact force.

Free Piston Drives Piles

LIGHTNESS, mobility and compactness are claimed for a recently announced pile-driving hammer. Operating mechanism of the hammer is a single free piston operating on diesel fuel. Built by McKiernan-Terry Corp., the internal-combustion pile hammer is said to be the first built by a U. S. pile-driving equipment firm. A 3000-lb ram of this type will deliver from 45 to 50 blows per minute with average energy per blow of 18,000 lb-ft.

Method of operation is relatively simple. To initiate the operating cycle a line lifts the piston until the dog is automatically released. The piston then falls downward in the cylinder. As it moves downward, the piston closes the exhaust ports and actuates a fuel pump to deliver a charge of fuel into the cup-shaped anvil block. When the ram strikes the anvil block the fuel is atomized by the blow and then ignited by the heat of compression. Expansion of the burning gases then propels the piston upward and the anvil block down to combine a push with the impact of the falling piston. As the piston travels upward it uncovers the exhaust ports to permit scavenging of the burned gases. When the top of the stroke is reached, the piston starts to fall and the cycle is repeated. The cycle is stopped when necessary by retracting the fuel pump operating cam by pulling an attached cord.



Length of stroke and timing are automatically regulated by pile resistance. If resistance is high a greater portion of the available energy is used in raising the piston. Low pile resistance results in greater downward travel of the entire assembly with less relative upward motion of the piston.

Contemporary Design

Criteria for

Evaluating Servo System

By J. M. Nightingale
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ANALYTICAL methods for assessing servo system performance were discussed in the first installment of this article. Various methods for determining system stability and response were considered with a view to obtaining optimum design values for the various system parameters. This portion of the article will deal with further facets of servo performance evaluation.

Steady-State Errors: Apart from sensitivity and stability another important factor in assessing performance is accuracy. Obviously, in any servo, high static accuracy is essential. A measure of static accuracy is given by the steady-state error in the response to a unit step function input $U(t)$, Fig. 10*a*.

In some systems dynamic accuracy is also very important. That is, following errors to continuously varying inputs must be very small. To assess the dynamic accuracy, the steady-state error when following an input which is increasing at unit rate can be easily found. In the case of position servos this input $U(t)t$ is called a *unit step velocity*, Fig. 10*b*.

Occasionally, in some position control servos, the output must be able to follow, with a small steady error, a constant acceleration input. Such an input is the *unit step acceleration* $U(t)t^2/2$. The difficulties involved here will shortly be discussed.

The relationship between the error and input is

$$\frac{e}{\theta_i}(s) = \frac{1}{1 + Y_o(s)} \tag{18}$$

Substituting from Equation 7 gives

$$e(s) = \frac{\theta_i(s)}{\left[1 + \dfrac{Kf(s)}{s^r g(s)}\right]} \tag{19}$$

Now Theorem 8 (Ref. 2) is used to obtain the steady-state error. This is

$$e_s = \lim_{t \to \infty} [e(t)] = \lim_{s \to 0} [se(s)] = \lim_{s \to 0} \left[\frac{s^{r+1}\theta_i(s)}{s^r + K}\right] \tag{20}$$

since $f/g \to 1$ as $s \to 0$.

In the case of a unit step function $U(t)$, $\theta_i(s) = 1/s$, so that

$$e_s = \lim_{s \to 0} \left[\frac{s^r}{s^r + K}\right] \tag{21}$$

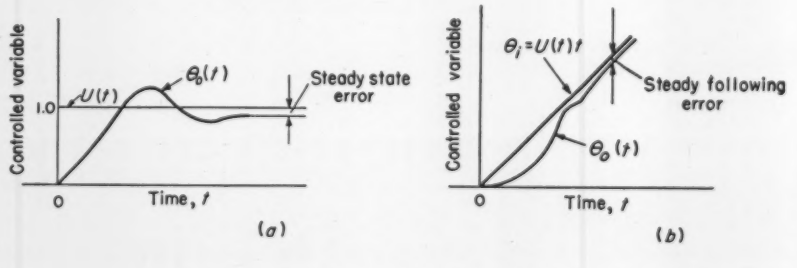


Fig. 10—Static accuracy of a servo system is indicated by the steady-state error in response to a unit step-function input, *a*. Dynamic accuracy can be assessed by finding the steady-state error in response to a unit step velocity input, *b*.

Performance
Part 2

Steady-state errors
Nyquist plot
Transient response
Relative damping

Obviously, for zero steady-state error, the requirement is that $r \geqq 1$. If $r = 0$, there is a static error of $e_s = 1/(1 + K)$. For a unit velocity step input $\theta_i(t) = U(t)t$, $\theta_i(s) = 1/s^2$. Therefore,

$$e_s = \lim_{s \to 0} \left[\frac{s^{r-1}}{s^r + K} \right] \qquad (22)$$

where the integer, r, is called the *order* of the servo.

Thus for zero steady following error $r \geqq 2$ is required. If $r = 1$, there is a steady following error $e_s = 1/K$. If $r = 0$, then the following error increases without limit. In other words, the servo is incapable of following the input.

This approach leads to Table 3 which can be extended at will and is symmetrical apart from the first term. As the table shows, a first order servo ($r = 1$) has a zero static error, but a finite steady following error to a step velocity input. A second-order servo has a zero steady following error for a step velocity input. For this reason second-order servos are frequently called *zero-velocity-error servos*, particularly in the case of displacement controllers.

Probably most mechanical servos are of the first-order kind. Where high dynamic accuracy is required, for example in gun-control systems, second and even third-order systems are sometimes used. Here there are inherent stability problems to be solved. This will be illustrated with a very simple example.

Suppose a second-order servo has the loop transfer function,

$$Y_o(s) = \frac{K}{s^2} \qquad (23)$$

where the effects of time lags have been neglected for simplicity. The characteristic equation is therefore

$$s^2 + K = 0 \qquad (24)$$

This has two imaginary roots $\pm j\sqrt{K}$, and so the system is unstable.

Now suppose the system loop transfer function

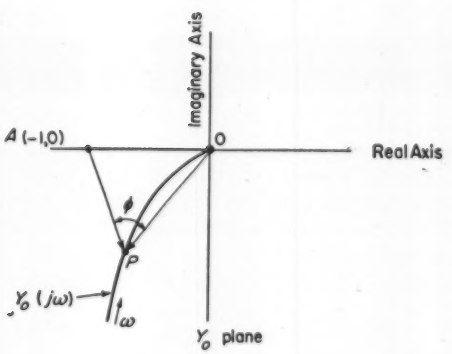


Fig. 11—The vector *OP* in this typical Nyquist plot represents the value of Y_o $(j\omega)$ for some frequency, ω. The vector *AP* represents $1 + Y_o$ $(j\omega)$. The overall response function is found by dividing *OP* by *AP*.

Table 3—Steady Following Errors of Servos

Input $\theta_i(s)$	Order r	Steady Error e_s
$1/s$	0	$1/(1 + K)$
	1	0
	2	0
	3	0
	4	0
$1/s^2$	0	∞
	1	$1/K$
	2	0
	3	0
	4	0
$1/s^3$	0	∞
	1	∞
	2	$1/K$
	3	0
	4	0

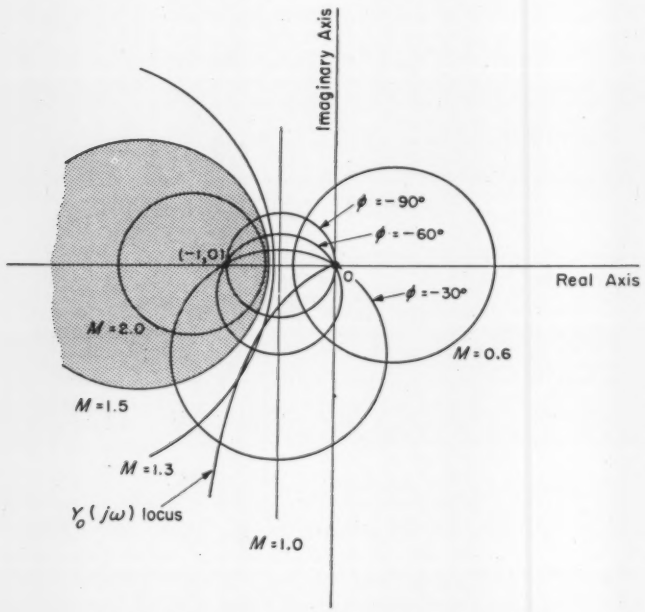
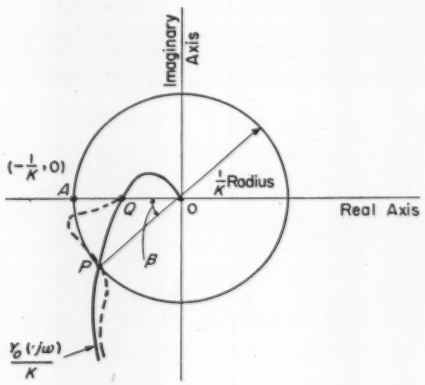


Fig. 12—Left—Plotting a series of orthogonal circles representing constant M and ϕ in the same plane as the Nyquist plot simplifies determination of the maximum amplitude ratio, M. The servo having the loop response plotted here has a maximum amplitude ratio of 1.3.

Fig. 13—Below—One way of insuring satisfaction of the Nyquist criterion is to move the critical stability point by changing the value of K, the scalar gain constant. Construction insures that the $Y_o(j\omega)$ locus just touches the required M value to fix the optimum value of K.



is modified to

$$Y_o'(s) = \frac{K(1 + Ts)}{s^2} \qquad (25)$$

The characteristic equation is now

$$s^2 + KTs + K = 0 \qquad (26)$$

The system is now stable, and still retains its zero-velocity-error characteristics. This type of problem will be investigated more thoroughly in a later article.

Performance Characteristics from Nyquist Plot: In a typical Nyquist plot, Fig. 11, the vector $\overline{OP}$ represents $Y_o(j\omega)$ for some particular frequency ω. Then to the same scale the vector $\overline{AP}$ represents $1 + Y_o(j\omega)$. Then the overall response function can be found by division (Ref. 2, Page 80). Thus

$$Me^{j\phi} \equiv Y_c(j\omega) = \frac{\overline{OP}}{\overline{AP}}$$

Results of this division are $M(\omega) = (OP)/(AP)$ (ratio of lengths) and $\phi(\omega) = \psi - \gamma = OPA$ (negative as shown).

Performing this process for a number of frequencies permits plotting of $M(\omega)$ and $\phi(\omega)$. This is a rather tedious task. It can however be avoided by superposing curves of constant M and ϕ on the Y_o plane. These contours are orthogonal circles, Fig. 12. M contours have their centers at $[-M^2/(M^2 - 1) + j0]$ and radii of $|M/(M^2 - 1)|$. The ϕ contours have their centers at $[-\frac{1}{2} - \frac{1}{2}j \cot \phi]$ and radii of $|\frac{1}{2} \operatorname{cosec} \phi|$.

If as previously suggested the maximum amplitude ratio is limited to 1.5, then the region shown shaded in Fig. 12 is prohibited. The servo having the loop response shown plotted in Fig. 12 obviously has a maximum overall amplitude ratio of 1.3.

Since changing the scalar gain constant K changes the scale of the Nyquist plot it obviously must be set so that the curve does not enter the prohibited region. The best way to do this is first to plot a curve of

$$\frac{f(j\omega)}{(j\omega)^r g(j\omega)}$$

which is just $Y_o(j\omega)$ with K omitted. Then the critical stability point is $(-1/K, 0)$ instead of $(-1, 0)$, Fig. 13. Thus instead of altering the contour when K is changed, the critical stability point is moved until the contour is in the right position relative to it. Unfortunately, changing the critical stability point involves changing the scale and lo-

cation of the M and ϕ constant contours. There are constructions for insuring that the critical stability point $(-1/K, 0)$ is positioned so that the $Y_o(j\omega)$ locus just touches the required M contour, thus fixing the optimum value of K.

These constructions are somewhat complicated and some prefer a simpler method involving two figures of merit known as the *gain margin*, G, and *phase margin* β, Fig. 13. Desired values are: G from 0.5 to 0.8, and β from 35 to 45 degrees. Thus once the point A and hence the value K have been fixed to agree with these figures, it is possible to plot $Y_o(j\omega)$ to the correct scale on a graph containing contours of constant M and ϕ.

Value of the gain margin and phase margin is purely their use in obtaining very simply an approximate best gain constant K. They are not reliable figures of merit to assess performance, although some have used them as such. The danger of doing this is demonstrated by the dotted response shown in Fig. 13. Although this satisfies the optimum values of G and β, the curve comes very close to the critical point and has a high maximum M. Thus the value of K would have to be much less than that predicted by the above method, unless the locus is modified to give better characteristics in the neighborhood of the critical point. That is probably what would happen.

The order of the servo and therefore its steady-state errors are also revealed by the Nyquist plot. This is because $Y_o(j\omega)$ behaves like $K/(j\omega)^r$ at low frequencies. Thus for $r = 1$, the curve approaches the negative imaginary axis asymptotically, Fig. 14. While for $r = 2$ the loop response locus approaches the negative real axis asymptotically, and so on. This is particularly useful if only an experimental Nyquist plot is available. Then if the order can be found and K is known, the steady-state errors can be obtained from Table 3.

As previously stated, second and higher-order

Table 4—Whitely's Optimum Parameters

Servo Order		Coefficients					Buildup Time	Overshoot, max.
r	n	C_1	C_2	C_3	C_4	C_5	ΩT_b	
1	2	1.4	1	—	—	—	3.3	0.045
1	3	2	2	1	—	—	3.8	0.08
1	4	2.6	3.4	2.6	1	—	4.2	0.10
2	2	2.5	1	—	—	—	0.85	0.10
2	3	6.3	5.1	1	—	—	1.65	0.10
2	4	12	16	7.2	1	—	2.65	0.10
2	5	18	38	29	9	1	3.85	0.10

Based on response to a unit step input.

Nomenclature

$e(s)$ = Transformed error
G = Gain margin
K = Scalar gain constant
$M(\omega)$ = Modulus of $Y_c(j\omega)$
r = Order of servo
T = Time constant
$U(t)$ = Unit step function
$Y_c(j\omega)$ = Overall harmonic response function
$Y_o(s)$ = Loop transfer function
β = Phase margin
$\theta_i(s)$ = Transformed input
$\theta_o(s)$ = Transformed output
$\phi(\omega)$ = Phase or argument of $Y_c(j\omega)$

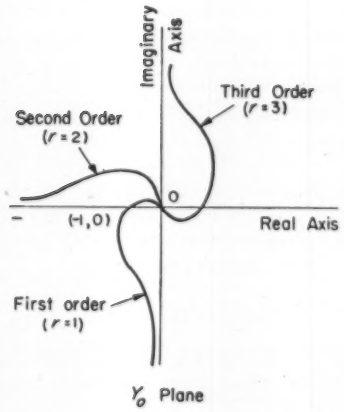
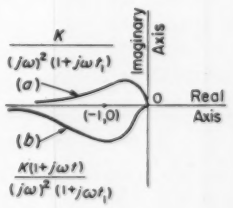


Fig. 14—Nyquist plots may be used to determine the order, r, of a servo because $Y_o\ (j\ \omega)^r$ behaves like $K/(j\ \omega)^r$ at low frequencies. Generalized Nyquist plots for first, second and third-order servos are shown.

Fig. 15—A second-order servo with one time lag in the loop is seen to be unstable, *a*. The system can be made conditionally stable, *b*, by modifying the response function and making T sufficiently large.



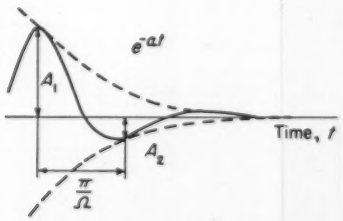


Fig. 16 — Time required for oscillation caused by a transient to die away is determined by the value of α. The ratio, α/Ω determines the decay in amplitude per cycle of oscillation. An accepted minimum value of α/Ω for a suitably stable servo is 0.5.

servos are inherently unstable. Curve *a*, Fig. 15 shows a second-order servo with one time lag in the loop, which can be represented by the response function,

$$Y_a(j\omega) = \frac{K}{(j\omega)^2(1 + j\omega T_1)} \quad (27)$$

This is seen to be unstable. By modifying the response function to

$$Y_a'(j\omega) = \frac{K(1 + j\omega T)}{(j\omega)^2(1 + j\omega T_1)} \quad (28)$$

the system can be made conditionally stable if T is large enough.

Transient Response Criteria from Transfer Function: As stated previously, it is not practical to attempt to express the transient response in terms of the system parameters. Indeed if $n > 4$, then this is not possible. However, an attempt has been made to give relations between the parameters for certain optimum types of response.

Whiteley's figures, Table 4, are normally for a slightly overdamped response (all roots of characteristic equation real and negative). The figures are given for systems according to their order r and the degree n of the characteristic equation. Whiteley considers a system with a loop transfer function of the form,

$$Y_a(s) = \frac{C_{r-1}\Omega^{n-r+1}s^{r-1} + C_{r-2}\Omega^{n-r+2}s^{r-2} + \ldots}{C_n s^n + C_{n-1}\Omega s^{n-1} + \ldots} \quad \frac{+ \Omega^n}{+ C_r \Omega^{n-r} s^r} \quad (29)$$

and Table 4 quotes his figures for the coefficients C, the maximum overshoot and the build-up time. To illustrate the use of the table, a second-order servo with a fifth-degree characteristic equation will be considered. By substituting values from Table 4 in Equation 29

$$Y_o(s) = \frac{18\Omega^4 s + \Omega^5}{s^2(s^3 + 9\Omega s^2 + 29\Omega^2 s + 38\Omega^3)} \quad (30)$$

The scalar gain factor, $K = \Omega^2/38$. Hence the build-up time $T_b = 3.85/\Omega = 0.625/\sqrt{K}$.

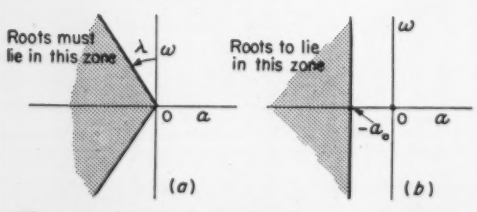


Fig. 17—If 0.5 is accepted as a minimum for α/Ω, all roots of the characteristic equation must fall within the shaded zone at *a*. If all roots fall within the shaded zone at *b*, total oscillations will decay in time determined by α_0.

Relative Damping Criterion: Transient response to a step function is largely determined by the roots of the characteristic equation $G(s) = 0$. A root of the form $s = -\alpha + j\Omega$ gives rise to a term of the form

$$Ae^{-\alpha t}(\sin \Omega t + \cos \Omega t) \quad (31)$$

As previously stated, the magnitude of α fixes the time taken for this particular component oscillation to die away. The ratio α/Ω determines the decay of amplitude per cycle of oscillation. Some fix the minimum value of this ratio as $\alpha/\Omega = 0.5$. This gives a decay in the ratio of 0.206 per half-cycle. That is $A_2/A_1 = 0.206$ in Fig. 16.

If 0.5 is used as the minimum ratio of α/Ω for each root of the characteristic equation, all the roots must lie in the region of the s plane shown shaded in Fig. 17*a*. Making this restraint permits the Nyquist and Algebraic stability criteria to be modified so that they become relative as well as absolute criteria. This can be most easily done with the algebraic criteria. The modified characteristic equation is

$$G'(s) \equiv G_1(s)\,G_2(s) = 0 \quad (32)$$

where

$$G_1(s) = a_n s^n + a_{n-1} e^{-j\lambda} s^{n-1} + \ldots + a_1 e^{-(n-1)j\lambda} s + a_0 e^{-nj\lambda}$$

$$G_2(s) = a_n s^n + a_{n-1} e^{j\lambda} s^{n-1} + \ldots + a_1 e^{(n-1)j\lambda} s + a_0 e^{nj\lambda}$$

and

$$\tan \lambda = \frac{\alpha}{\Omega} \quad (33)$$

Equation 32 is a polynomial in s with real coefficients, so Hurwitz' criterion can be applied. This yields desired relationships between the system coefficients. The method may involve some tedious numerical work since the degree of the characteristic equation is doubled. Some simplifying techniques have been developed, Ref. 6, Page 25 but these are too lengthy to discuss here.

Others have developed similar criteria locating the roots in other restricted regions of the s plane. For instance, to insure that all roots are in the shaded region in Fig. 17*b*, magnitude of all the real parts of the roots is made greater than a certain value α_0. This means the total oscillations will decay within a time determined by α_0.

References

This article is the fourth in a co-ordinated group by J. M. Nightingale on servo systems. Previous articles, and the issues of MACHINE DESIGN in which they appeared, are:

1. "Automatic Control Systems" ..... May 17, 1956
2. "Servo Mathematics" ..... June 28, 1956
3. "Evaluating Servo System Performance—Part 1" ..... July 26, 1956

Other helpful sources of information on points discussed in this article are:

4. W. R. Evans—*Control System Dynamics*, McGraw-Hill Book Co., New York, 1954.
5. H. M. James, N. B. Nichols and R. S. Phillips—*Theory of Servomechanisms*, McGraw-Hill Book Co. Inc., New York, 1948.
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A tabular method for Calculating Deflections of

Stepped and Tapered Shafts

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FINDING deflections of shafts is often necessary when clearances are being investigated or whirling critical speeds are calculated. When shafts are stepped and tapered, standard deflection formulas available in handbooks are not applicable. Special methods have been devised for these complicated cases. References 1 and 2 (listed at end of article) describe graphical methods; Reference 3 develops a finite-difference approximation.

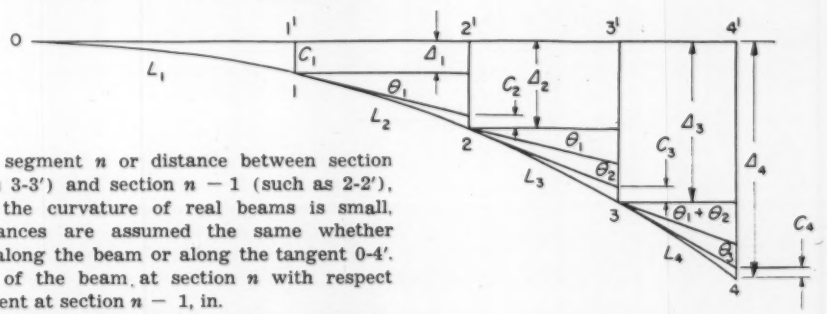
This article presents a tabular method which is a generalization and extension of a concept used in References 4 and 5. The method requires only simple algebra. It is as "exact" as any method based on the elementary theory of bending (double integration, area-moments, conjugate beam) and requires, in addition to a simple fundamental formula, only deflection formulas for cantilever beams.

Extensions of the method are possible for shafts whose diameters vary in any manner, provided the definite integrals which result can be evaluated. The method is applicable to both statically determinate and statically indeterminate shafts. It is useful in the analysis of deflections in journal bearings for which classical methods, requiring precise boundary conditions, may prove inadequate.

Deflections produced by shear also may be calculated, either separately or in conjunction with the bending deflections.

Fundamental Equation: Consider any portion of a bent beam, Fig. 1, which has been arbitrarily divided into four segments by points 1, 2, and 3.

Fig. 1—Layout of bent beam, with nomenclature, for development of fundamental equation used in tabular method.



L_n = Length of segment n or distance between section n (such as 3-3') and section $n-1$ (such as 2-2'), in. Since the curvature of real beams is small, these distances are assumed the same whether measured along the beam or along the tangent 0-4'.

C_n = Deflection of the beam at section n with respect to the tangent at section $n-1$, in.

θ_n = Angle between the tangent at section n and the tangent at section $n-1$, radians.

Δ_n = Deflection of the beam at section n with respect to the tangent at section 0, in.

Curvature of the beam is shown greatly exaggerated. The tangent to the elastic curve at point 0 is 0-4′. Tangents have also been drawn at points 1, 2, and 3.

The objective is to find expressions for distances 1-1′, 2-2′, 3-3′, 4-4′, which represent the deflections of the beam from the tangent at point 0. By inspection of Fig. 1,

$$\Delta_1 = C_1$$

$$\Delta_2 = \Delta_1 + C_2 + L_2\,\theta_1$$

$$\Delta_3 = \Delta_2 + C_3 + L_3\,(\theta_1 + \theta_2)$$

$$\Delta_4 = \Delta_3 + C_4 + L_4\,(\theta_1 + \theta_2 + \theta_3)$$

In general,

$$\Delta_n = \Delta_{n-1} + C_n + L_n\,(\theta_1 + \theta_2 + \ldots + \theta_{n-1}) \qquad (1)$$

This is the fundamental equation for the method.

In Fig. 1, the division points on the elastic curve are placed at random. On an actual beam, the choice of these points is determined by the distribution of the loads on the beam and the location of the steps, as will be demonstrated by later examples.

It is apparent that determining the values of C and θ for the various segments of a beam requires only formulas for cantilever beams. At section 3 in Fig. 1, for example, the beam is caused to rotate and deflect with respect to the tangent at 2 by one or all of the following:

1. Shear at section 3.
2. Bending moment at section 3.
3. Any distributed loads (weight, for example) acting on the beam between sections 2 and 3.

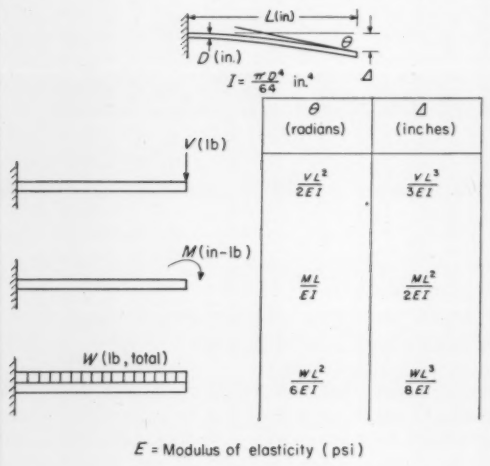


Fig. 2—Deflection formulas for straight cantilever beams of circular cross section.

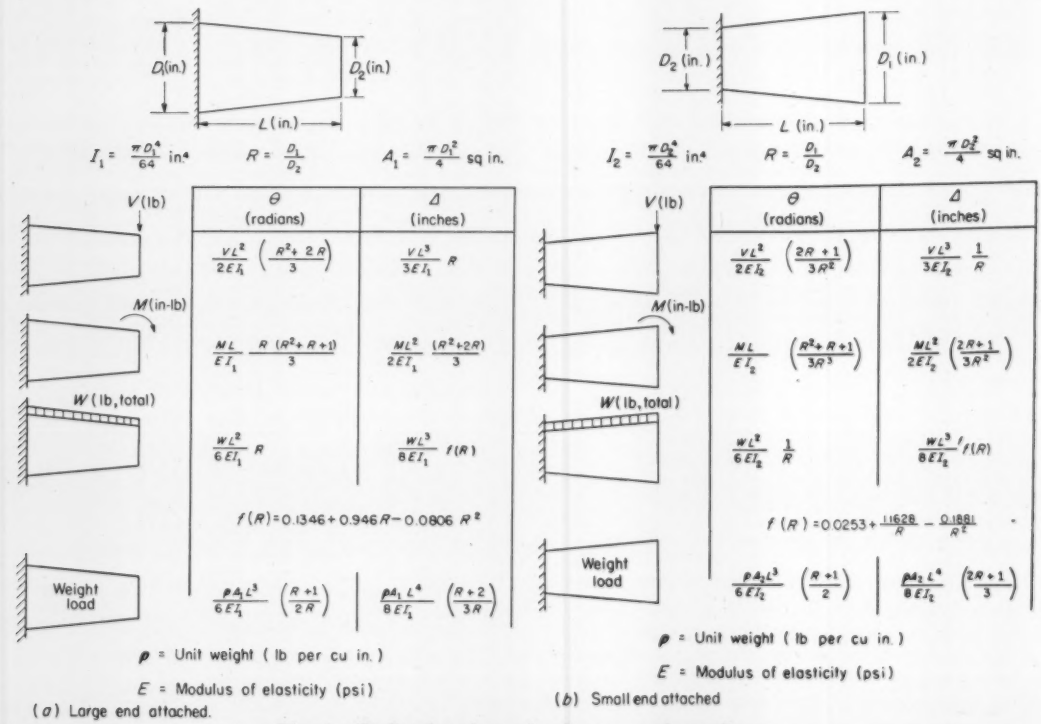


Fig. 3—Deflection formulas for tapered cantilever beams of circular cross section.

Standard formulas for straight cantilever beams are shown in Fig. 2, and similar formulas for tapered cantilevers in Fig. 3. Methods used to set up formulas for tapered cantilevers are discussed in the Appendix.

Deflection Curve: The first step in the solution of a shaft deflection problem is to divide the shaft into appropriate segments. An imaginary horizontal line is then assumed drawn tangent to the deflection curve at any of the sections or division points or at either end of the beam. Unloaded overhanging segments at the ends of the beam are disregarded, since they remain straight and can be easily taken care of later.

Less work is usually entailed if the tangent line is assumed at one of the division points near the center of the beam. The deflections of the various sections are then calculated with respect to the imaginary tangent — first to the left and then to the right of the point of tangency. By inspection, it is easy to tell whether the shear and moment loadings on the various sections will cause the section to be bent upward or downward from the horizontal tangent. In this discussion, it is assumed that shears, moments, and loads on the beam which bend the beam upward are positive and those which bend it downward are negative.

Assume that the described calculations have been made for a specific beam and that the results are shown in Fig. 4.

The tangent line is $0X$ and the elastic curve is ab. If the shaft is supported on bearings at 1 and 2, the actual shaft deflections from the center line of the bearings are given by the vertical distances from the diagonal line through 1 and 2 to the elastic curve.

All deflections must be measured vertically (i.e., parallel to the $0Z$ axis) and not perpendicular to line 1-2. Also, the length of the beam is $0X$, not ab, and the axial location of points on the beam is made along $0X$.

The equation of the reference line 1-2 is

$$z = \frac{z_2 - z_1}{x_2 - x_1}(x - x_1) + z_1 \qquad (2)$$

Since x_1, x_2, z_1, and z_2 are known constants, an expression can be developed for z as a function of x. Then, substituting for x the various distances from 0 for which deflections to the elastic curve have been calculated gives a series of values of z. The true deflection of the beam from the bearing center line will then be $y = \Delta - z$ for each value of x.

Examples 1 and 2 demonstrate application of the foregoing ideas.

Statically Indeterminate Shafts: The procedure for finding deflections along statically indeterminate shafts can be outlined in reference to the shaft shown in Example 1. Assume that the shaft has fixed ends. The deflections may be obtained in the following steps:

1. To start, assume that the ends are freely supported, and obtain the reactions by statics (i.e., as in Example 1).

2. Taking the 0 section at the right end, calculate the deflections at each section with respect to the tangent at the right end. Obtain also the net rotation of the left end with respect to the right end (summation of θ for sections 1 to 6).

3. Remove the given loads from the shaft, fix it at the right end, load it at the left end with a force P and a moment M, and repeat the calculations made in Step 2. Results will be in terms of P and M.

4. Since, with fixed ends, the net rotation and deflection of the left end with respect to the tangent at the right end must be zero, the sums obtained from Steps 2 and 3. added together, must equal zero. The two equations thus obtained will yield numerical values of P and M.

5. Using the values of P and M obtained in Step 4, put the results obtained in Step 3 in numerical form.

6. Add the results of Steps 2 and 5, and the de-

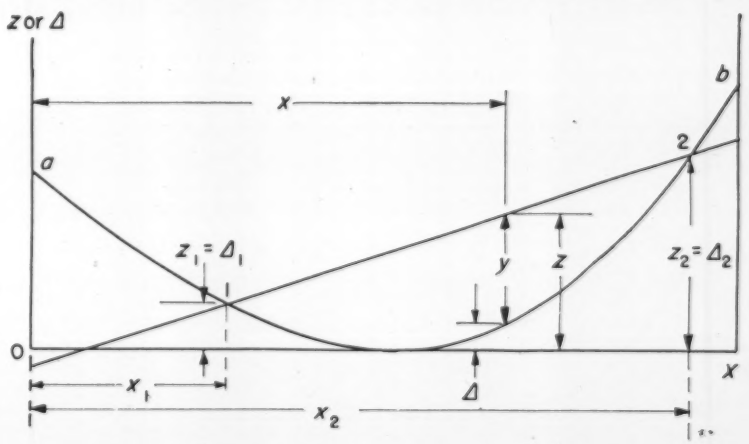


Fig. 4—Characteristic deflection curve with nomenclature.

Example 1—Stepped Shaft

A representative problem is detailed in the accompanying sketch (*a*). The problem is to find the deflection curve of the shaft.

It will be best to assume the tangent drawn at the center of the beam (section 0). At least three segments to the left of section 0 and three to the right are needed for the following reasons:

1. All segments must have either a uniform diameter throughout or a straight uniform taper.
2. There must be no concentrated loads acting along the length of a segment.
3. Only uniformly distributed loads are permitted along the length of a segment (e.g., the weight of the shaft). If a nonuniformly distributed load should act on any segment, special cantilever beam formulas would have to be developed.

The tabular calculations, (*b*) clarify the details of the procedure. Note that columns headed 1, 2, and 3 give the three contributions to θ, the rotation of the tangents, and that the formulas are given in Fig. 2. Modulus of elasticity E is assumed constant and will be introduced later. Columns headed 5, 6 and 7 give the three contributions to C, the cantilever deflection, and the formulas are also given in Fig. 2. The $E\Delta$ column is obtained by repeated application of Equation 1.

For example, on the right side

$$E\Delta_3 = 1839 + 6390 + 3\,(827 + 378)$$

$$= 11{,}844$$

For a steel shaft,

$$\Delta_3 = \frac{11{,}844}{30 \times 10^6} = 394.8 \times 10^{-6} \text{ in.}$$

Note that shear force V at section 2 on the left side is that which is acting on segment 2 and must be taken to the right of the 20-lb load. This procedure must be used, also, when the bending moment diagram changes abruptly at a section (e.g., where couples are applied at specific points on a beam).

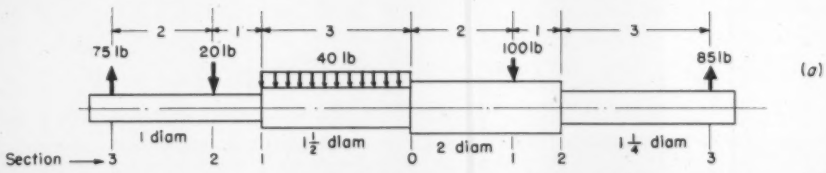
Results obtained from the work table are shown in the graph at *c*.

If the bearings are at the ends of the beam, the equation of the diagonal 3-3 will be (nomenclature, Fig. 4)

$$z \times 10^4 = \left(\frac{9.36 - 3.95}{12}\right) x + 3.95$$

$$= 0.45\,x + 3.95 \text{ in.}$$

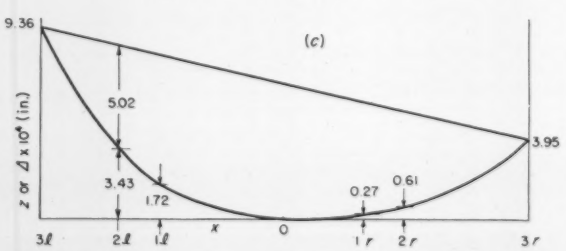
Shaft deflections from the center line of the bearings are given in the last column of the section summary table, *d*.



$E = 30 \times 10^6$ psi

(b)

Side	Section	Segment	L (in)	L^2 (in^2)	L^3 (in^3)	I (in^4)	V (lb)	M (in-lb)	W (lb)	1 $\frac{VL^2}{2I}$	2 $\frac{ML}{I}$	3 $\frac{WL^2}{6I}$	4 $E\theta = \Sigma(1,2,3)$	5 $\frac{VL^3}{3I}$	6 $\frac{ML^2}{2I}$	7 $\frac{WL^3}{8I}$	8 $EC = \Sigma(5,6,7)$	$E\Delta$	$\Delta \times 10^6$ (in)
Left		1							-40			-241				-542			
	1		3	9	27	.249	+55	+205		+995	+2470	-241	+3224	+1990	+3710	-542	+5158	+5158	+1719
		2																	
	2		1	1	1	.049	+55	+150		+561	+3060		+3621	+374	+1530		+1904	+10,286	+342.9
		3																	
	3		2	4	8	.049	+75	0						+4075			+4075	+28,051	+935.0
Right		1																	
	1		2	4	8	.785	-15	+340		-38	+865		+827	-51	+865		+814	+814	+27.13
		2																	
	2		1	1	1	.785	+85	+255		+54	+324		+378	+36	+162		+198	+1839	+61.3
		3																	
	3		3	9	27	.120	+85	0						+6390			+6390	+11,844	+394.8



Section	x (in.)	$z \times 10^4$	$\Delta \times 10^4$	$y \times 10^4$
$2r$	3	5.30	0.61	4.69
$1r$	4	5.75	0.27	5.48
0	6	6.65	0	6.65
1ℓ	9	8.00	1.72	6.28
2ℓ	10	8.45	3.43	5.02

(*d*)

Example 2—Stepped and Tapered Shaft

The shaft shown at *a* is the one which is solved in Reference 2 by graphical means. The 3500-lb and 1600-lb uniformly distributed loads are assumed to be the reactions produced by rigid plain bearings. The deflection of the shaft at the bearing ends is of interest, since sufficient clearance must be provided to prevent binding at these points.

The solution of the problem is shown in the tabular calculations, *c* and *d*. For convenience, section 0 is located at the right end of the left bearing. A minimum of 11 segments is necessary—four to the left and seven to the right.

To save space, the segment column used in Example 1, has been eliminated. At section 3 on the left side, for example, the value of L, to be used in calculations of θ and C for the tapered cantilever, fixed at section 2, must be 11. On the right side, the correct L for any section will lie to the left of the section.

The solution of the problem, step by step, is self-evident from *c* and *d*. For the tapered segment (see section 3, columns 1, 2, 4, and 5 for the left side), calculations were first made for a straight cantilever having a diameter equal to that at the large end. The correct functions of R were then obtained from Fig. 3*a* and calculated at the bottom of the left-side table. The corrected values were then inserted in columns 1, 2, 4, and 5, and the initial values crossed out.

Note that additional summation columns have been used on this example. These make the work automatic, and simplify the application of Equation 1.

The shaft deflections from the tangent at 0 are shown plotted at *b*. Deflections from the center line of the bearings will be obtained by the method given in Reference 2. In Reference 2, however, certain constructions were made graphically; this example demonstrates a simple algebraic procedure.

The equation of the bearing reference line can be easily obtained by considering sketch *e*. It is the line which passes through the midpoints of the straight lines connecting the deflections at the ends of each bearing.

With the nomenclature of Fig. 4,

$$x_1 = 16 \text{ in.}, z_1 = \frac{\Delta_{11}}{2} = -0.2403 \times 10^{-3} \text{ in.}$$

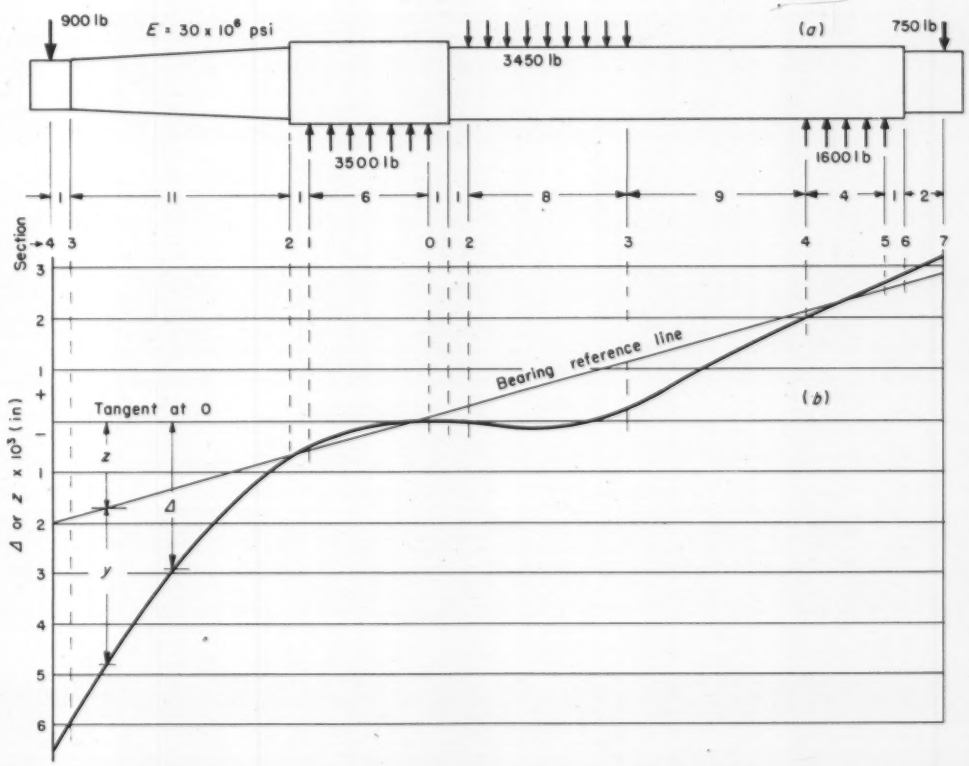
$$x_2 = 40 \text{ in.}, z_2 = \frac{\Delta_{5r} + \Delta_{4r}}{2} = 2.3449 \times 10^{-3} \text{ in.}$$

From Equation 2 the reference line is

$$z = \left[\frac{2.3349 + 0.2403}{24} (x - 16) - 0.2403 \right] \times 10^{-3}$$

$$= (0.1077\,x - 1.9635) \times 10^{-3} \text{ in.}$$

The value of z was calculated for each section and the results are shown in the table at *f*. The shaft deflections from the bearing reference line ($y = \Delta - z$) and those given in Reference 2 are shown in the last two columns. The agreement is excellent, except at the left bearing, where the small deflections make graphical construction difficult.



Example 2—Stepped and Tapered Shaft

(c) Left side

Section	L (in.)	L^2 (in.^{2})	L^3 (in.^{3})	D (in.)	I (in.^{4})	V (lb)	M (in-lb)	W (lb)	1 $\frac{VL^2}{2I}$	2 $\frac{ML}{I}$	3 $\frac{WL^2}{6}$	4 $\frac{VL^3}{3I}$	5 $\frac{ML^2}{2I}$	6 $\frac{WL^3}{8I}$
1	6	36	216	4	12.57	-900	-11,700	+3500	-1290	-5590	+1671	-5160	-16,770	+7510
2	1	1	1	4	12.57	-900	-10,800		-36	-860		-24	-430	
3	11	121	1331	$3\frac{1}{2}$ / $2\frac{1}{2}$	7.37	-900	-900		~~-7380~~ -11,700	~~-1341~~ -2740		~~-54,290~~ -76,000	~~-7390~~ -11,700	
4	1	1	1	$2\frac{1}{2}$	1.92	-900	0					-156		

Section	L (in.)	$E\Theta = \sum$Col. 1,2,3	$\sum E\Theta$	7 $L_n \sum_{n-1} E\Theta$	8 $EC = \sum$Col. 4,5,6	9 Col. 7 + Col. 8	$E\Delta = \sum$Col. 9	$\Delta \times 10^3$ (in.)
1	6	-5209	-5209		-14,420	-14,420	-14,420	-0.481
2	1	-896	-6105	-5209	-454	-5663	-20,083	-0.669
3	11	-14,440	-20,545	-67,155	-87,700	-154,855	-174,939	-5.831
4	1			-20,545	-156	-20,701	-195,640	-6.521

For tapered segment, section 3 : $R = \frac{3.5}{2.5} = 1.4$;

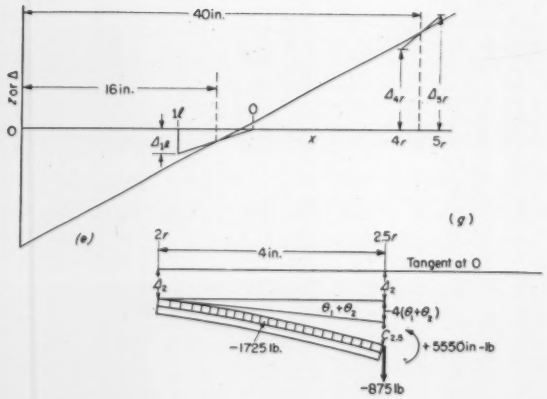
$\frac{R^2+2R}{3} = 1.59$; $R\ \frac{(R^2+R+1)}{3} = 2.04$

Col. 1, Factor 1.59
2 2.04
4 1.40
5 1.59

(d) Right side

Section	L (in.)	L^2 (in.^{2})	L^3 (in.^{3})	D (in.)	I (in.^{4})	V (lb)	M (in-lb)	W (lb)	1 $\frac{VL^2}{2I}$	2 $\frac{ML}{I}$	3 $\frac{WL^2}{6I}$	4 $\frac{VL^3}{3I}$	5 $\frac{ML^2}{2I}$	6 $\frac{WL^3}{8I}$
1	1	1	1	4	12.57	-2600	-4000		-104	-318		-69	-159	
2	1	1	1	$3\frac{1}{2}$	7.37	-2600	-1400		-176	-190		-118	-95	
3	8	64	512	$3\frac{1}{2}$	7.37	+850	+5600	-3450	+3690	+6075	-4990	+19,700	+24,300	-29,940
4	9	81	729	$3\frac{1}{2}$	7.37	+850	-2050		+4660	-2500		+27,960	-11,250	
5	4	16	64	$3\frac{1}{2}$	7.37	-750	-2250	+1600	-814	-1220	+578	-2160	-2440	+1734
6	1	1	1	$3\frac{1}{2}$	7.37	-750	-1500		-51	-203		-34	-102	
7	2	4	8	3	3.98	-750	0					-501		

Section	L (in.)	$E\Theta = \sum$Col. 1,2,3	$\sum E\Theta$	7 $L_n \sum_{n-1} E\Theta$	8 $EC = \sum$Col. 4,5,6	9 Col. 7 + Col. 8	$E\Delta = \sum$Col. 9	$\Delta \times 10^3$ (in.)
1	1	-422	-422		-228	-228	-228	-0.0076
2	1	-366	-788	-422	-213	-635	-863	-0.0288
3	8	+4775	+3987	-6304	+14,060	+7756	+6893	+0.2298
4	9	+2160	+6147	+35,883	+16,710	+52,593	+59,486	+1.9828
5	4	-1456	+4691	+24,588	-2 866	+21,722	+81,208	+2.7069
6	1	-254	+4437	+4691	-136	+4 555	+85,763	+2.8588
7	2			+8874	-501	+8373	+94,136	+3.1378



Sect.	x (in.)	$z \times 10^3$ (in.)	$\Delta \times 10^3$ (in.)	$y \times 10^3$ (in.)	$y \times 10^3$ (in.) Ref. 2
4ℓ	0	-1.9635	-6.5213	-4.5578	-4.55
3ℓ	1	-1.8558	-5.8313	-3.9755	
2ℓ	12	-0.6711	-0.6694	+0.0017	
1ℓ	13	-0.5634	-0.4806	+0.0828	+0.05
0	19	+0.0828	0	-0.0828	-0.12
1r	20	+0.1905	-0.0076	-0.1981	
2r	21	+0.2982	-0.0288	-0.3270	
3r	29	+1.1598	+0.2298	-0.9300	
4r	38	+2.1291	+1.9828	-0.1463	-0.15
5r	42	+2.5599	+2.7069	+0.1470	+0.15
6r	43	+2.6676	+2.8588	+0.1912	
7r	45	+2.8830	+3.1378	+0.2548	+0.24

(f)

If desired, the shaft deflections in any small region of the shaft (e.g., in a bearing) can be investigated in more detail. An example is the region loaded with the 3450-lb uniformly distributed load, between sections 2 and 3 on the right side. Shear, moment, and intermediate loads acting on the segment are shown in sketch *g*. In the same manner as for column 8 in *d*,

$$EC_{2.5} = \frac{-875\,(64)}{3\,(7.37)} + \frac{5550\,(16)}{2\,(7.37)} - \frac{1725\,(64)}{8\,(7.37)}$$

$$= 1620$$

From the table at *d*, $E\,\Delta_2 = -863$ and $E\,(\theta_1 + \theta_s) = -788$. Then, by Equation 1,

$$E\,\Delta_{2.5} = -863 + 1620 - 4\,(788)$$
$$= -2395$$

Next,

$$\Delta_{2.5} = \frac{-2395}{30 \times 10^6} = -0.0798 \times 10^{-3} \text{ in.}$$

With z_{2r} and z_{3r} from the table at *f*,

$$z_{2.5} = \frac{0.2982 + 1.1598}{2} = 0.7290 \times 10^{-3} \text{ in.}$$

Finally, since $y = \Delta - z$, $y_{2.5} = -0.8088 \times 10^{-3}$ in.

flection at each section will be obtained.

Shear Deflection: The deflections produced by shear are assumed to produce no changes in the angles between the cross sections of shaft. The sections move parallel to each other like a pack of cards. Due to this movement, the angle between the neutral surface and the section will become 90 degrees plus or minus the shear strain. Under a pure bending action, this angle is always 90 degrees, but due to the curvature of the neutral surface, the various cross sections will rotate with respect to each other.

Effects of shear, alone, on the deflections of a beam will be considered. In Fig. 5, a portion of a sheared beam is divided into three segments.

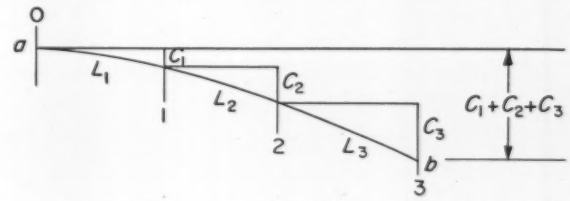
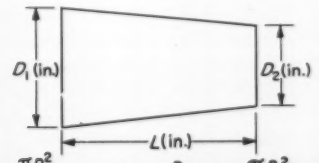


Fig. 5 — Layout of beam subjected to shear load.



$A_1 = \frac{\pi D_1^2}{4}$ sq in. $R = \frac{D_1}{D_2}$ $A_2 = \frac{\pi D_2^2}{4}$ sq in.

Type of Load	Shear Deflection (inches)	
	Large End Fixed	Small End Fixed
End Load, V (lb)	$\frac{10}{9}\,\frac{VL}{GA_1}\,R$	$\frac{10}{9}\,\frac{VL}{GA_2}\,\frac{1}{R}$
Weight Load	$\frac{5}{9}\,\rho\frac{L^2}{G}\left(\frac{R+2}{3R}\right)$	$\frac{5}{9}\,\rho\frac{L^2}{G}\left(\frac{2R+1}{3}\right)$
Uniformly Distributed Load, W (lb)	$\frac{5}{9}\,\frac{WL}{GA_1}\,f_1(R)$	$\frac{5}{9}\,\frac{WL}{GA_2}\,f_2(R)$

$f_1(R) = 0.280 + 0.8027\,R - 0.0827\,R^2$

$f_2(R) = 0.0832 + \frac{1.1954}{R} - \frac{0.2786}{R^2}$

ρ = Unit weight (lb per cu in.)

G = Shear modulus of elasticity (psi)

Fig. 6—Shear deflection formulas for tapered cantilever beams of circular cross section.

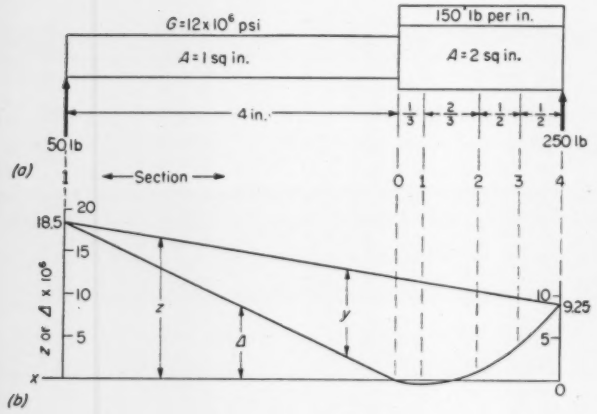
Example 3—Shaft Shear Deflection

The 0 section is located at the step (sketch *a*), and the calculations for the right side, *c*, are carried out in greater detail than is necessary in order to show the nature of the curve, *b*. The calculations are extremely simple.

Note that the horizontal reference line cuts the curve at two points. If the 0 section had been taken at section 1 on the right side, the reference line would have been tangent to the curve. At this point the shear is zero.

Note, also, that no matter which section had been chosen for the 0 section, the curve would have been identical with that shown. It would merely have been displaced up or down from the reference line. In this respect, the shear deflection curve differs from the bending deflection curve.

In *a* the bearings are assumed to be at the ends. and the *y* deflections are obtained in the same way that they are calculated for bending deflections. The *y* deflection at the 0 section is -12.33×10^{-6} in.



Section	L (in.)	A (in.²)	V (lb)	W (lb)	Left side 1 $\frac{10}{9}\frac{VL}{A}$	Left side 2 $\frac{5}{9}\frac{WL}{A}$	GC (1+2)	$G\Delta = \Sigma GC$	Δ x10⁶ (in.)	y x10⁶ (in.)
1	4	1	+50	0	+222	0	+222	+222	+18.5	0
Right side										
1	1/3	2	0	-50	0	-4.6	-4.6	-4.6	-0.38	-12.20
2	2/3	2	+100	-100	+37	-18.5	+18.5	+13.9	+1.16	-9.63
3	1/2	2	+175	-75	+48.6	-10.4	+38.2	+52.1	+4.34	-5.68
4	1/2	2	+250	-75	+69.4	-10.4	+59	+111.1	+9.25	0

(c) $z = 1.54x + 9.25$ $y = \Delta - z$

The reference line at section 0, from which all deflections will be measured, is perpendicular to section 0 but not necessarily tangent to the neutral surface *ab*. It would be tangent to the neutral surface at 0 only if there were no shear at section 0.

The deflection at section 3, with respect to the perpendicular to the section at 0, is obviously $C_1 + C_2 + C_3$, where C_1, C_2, and C_3 are the deflections given by the cantilever beam formulas in Fig. 6. Since the sections do not rotate, there are no rotation terms, and the fundamental formula for shear only is simply

$$\Delta_n = \sum_1^n C \qquad (3)$$

Example 3 shows a typical solution for shear deflections only.

The shear deflections in a shaft become significant only when the shaft is short in proportion to its diameters. They may be included in the calculation of the bending deflections by merely adding them to the *C* column in the calculation tables.

Appendix: Procedures used for determining the various tapered cantilever formulas, Figs. 3 and 6, can be summarized very briefly.

BENDING DEFLECTION: A conventional approach was employed for all formulas for Δ in Fig. 3. However, quadratic functions have been substituted for the true relations in Fig. 3 for the cases of uniformly distributed load—both large end fixed and small end fixed. The true factors are complex in form, and difficult to evaluate.

These approximations, fitted to the range of R from 1 to 3, have a maximum error of less than one per cent from $R = 1$ to 3 and 3 per cent or less when $R = 4$.

Formulas for angular deflection θ were obtained by integration of $M\,dx/EI$.

SHEAR DEFLECTION: Formulas for strain deflection were obtained by Castigliano's theorem which states that the derivative of the strain energy with respect to the load gives the displacement corresponding to the load.

Again, quadratic approximations are shown in Fig. 6 for both cases of uniformly distributed load. The error is 0.8 per cent maximum between $R = 1$ and $R = 3$.

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Design factors for

DESIGN ABSTRACTS

Controlling Manufacturing Costs

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SOME areas of quality, though limited, can be resolved into definable increments lending themselves to measurement. For instance, standards of dimensional tolerance and surface roughness are not new. Continuing in progressive steps of logic, it should therefore be feasible to track down cost patterns in relation to standardized quality increments.

At Warner & Swasey Co. these cost-behavior patterns were found hidden in the industrial engineering data designed for use in plant operational control. The cost patterns were not readily apparent because the data were in a language adapted only for other uses. If a way could be found to extract, translate and condense the information into a form meaningful at the drafting board, not only would it provide the design engineers with some of the information sought, but to a degree, implied gains in reduced engineering time and development expense would accrue from its broader use.

Industrial Engineer's Function: Since the function of an industrial engineer in any manufacturing organization is to translate product requirements into processing plans and labor time standards, the data compiled as a result of his activity should reflect cost information in defined form. A cursory examination of such data will prove the point. With the knowledge that time is one, though not the only, measure of cost, it should be possible to tabulate time or cost differentials for all standardized quality differentials. Such analysis of any industrial engineering data will readily reveal that not only does cost vary with varying quality specifications, but the degree of change is predictable.

Using the data available at Warner & Swasey, analyses were made to test the practicability of the idea and to verify that quality specifications and industrial engineering data could be compounded into simplified form. The findings demonstrated it was possible to plot variables of quality against variables of cost, resulting in charts that are easily understood and quickly read. The accompanying charts are examples of the results obtained.

Cost Comparison: Fig. 1 shows a representative cost-comparison chart in which cost is plotted with

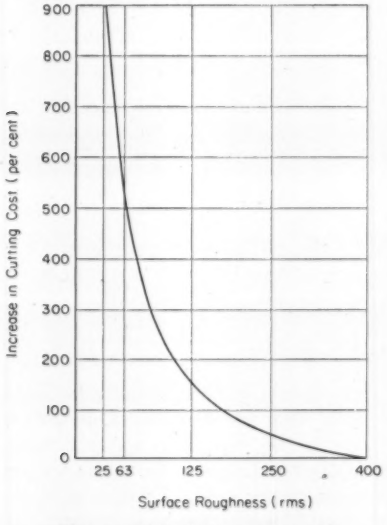

Fig. 1—Typical curve of surface quality vs cost for turning done on turret lathes.

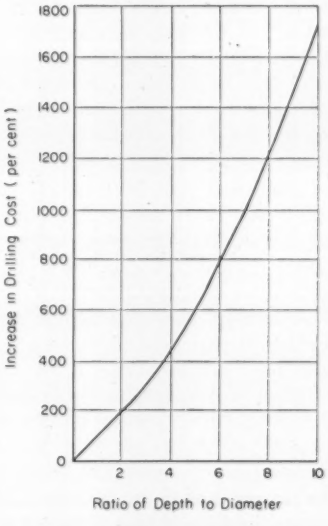

Fig. 2—Effect of depth of drilled holes on cost.

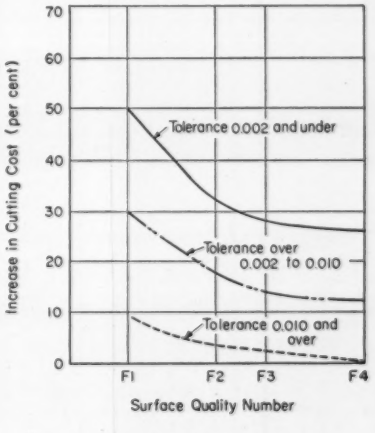

Fig. 3—Cost behavior for planing, showing effect of variations in surface quality and dimensional tolerance. Surface quality is defined by coded numbers, since rms values do not express the desired control.

respect to surface quality standards, and limited to the turning process as done on turret lathes. Note how easily the choice of functional surface quality for any application can be made, with full knowledge of comparative cost.

Drilled Holes: The chart in Fig. 2 was prepared to illustrate the cost behavior of one frequently occurring element of design, namely drilled holes. From the chart it is readily apparent that deep holes are expensive. Beyond the depth of three times the diameter, the cost rises more rapidly than equal increments of depth. It should be stated at this point that only standard drilling facilities were covered by the data. Special oil-hole drills or special trepanning tools would reflect cost patterns at variance with this chart. Such tools and supporting facilities are costly, however, and their use would have to be justified through amortization requiring prolonged product design life and quantity production.

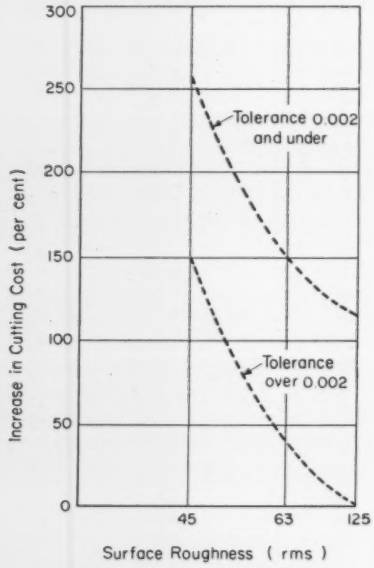

Fig. 4—Cost of face-milling related to surface quality and dimensional tolerance.

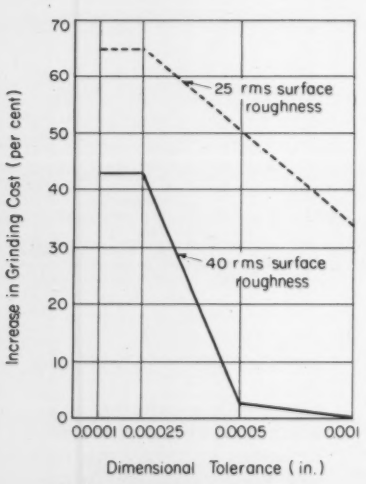

Fig. 5—Nonuniform cost-behavior pattern for cylindrical grinding.

Planing and Face-Milling: Though planing is not used extensively in industry, it was an important process in the plant covered by the data and provided quite comprehensive information. Fig. 3 is a cost-behavior chart on planing, demonstrating the effect of two quality variables; one being surface quality and the other dimensional tolerance. It should be noted how readily the quality variables can be judged in relation to each other. In this case, surface quality was defined by coded numbers supported with visual samples, since rms values did not express the desired control.

In Fig. 4 is an additional illustration of a cost-behavior chart combining the same two quality variables, but in this instance related to face-milling. It is interesting to note the wide cost differentials throughout the range of defined quality.

Cylindrical and Internal Grinding: The chart in Fig. 5, showing cylindrical grinding cost, is unique in that it exposes a nonuniform cost-behavior pattern. As can be seen the 40 microin. rms surface quality line shows a minor cost rise between the 0.001 and 0.0005-in. tolerances followed by an abrupt rise between the 0.0005 and 0.00025-in. tolerances. The 25 microin. rms surface quality line, on the other hand, reflects a more normal and usual cost behavior relative to tolerance.

In preparing the chart on internal grinding cost shown as Fig. 6, the intent was to expose some of the hidden elements that compound into the resultant cost behavior. From the chart it is apparent that, though reducing the tolerance increases the cost of grinding, substantial cost increases occur from the effects upon the machine operator in the form of increased gaging and dial-readjusting time.

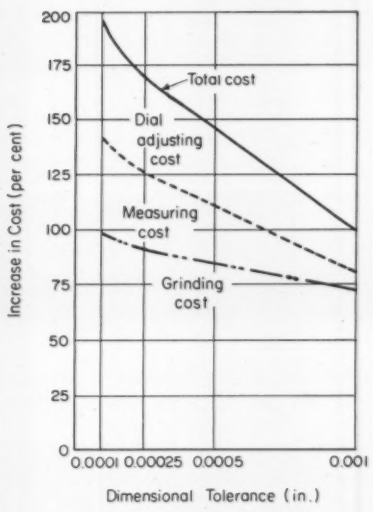

Fig. 6—Cost of internal grinding, showing elements of machine and operator costs which combine to give resultant cost.

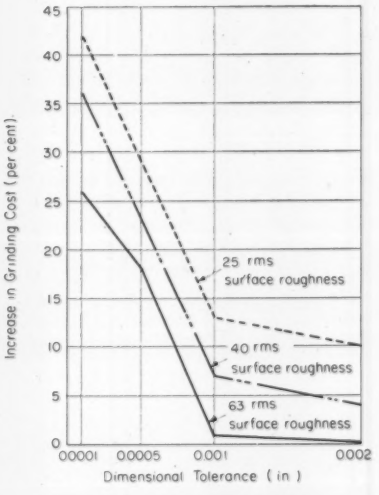

Fig. 7—Effects of dimensional tolerance and surface quality on cost of reciprocating surface grinding.

In reciprocating surface grind-

ing, the dimensional tolerance range has greater cost effect than the surface-quality range, as shown in Fig. 7. And in addition, it is apparent that cost rises sharply with tolerances less than 0.001-in.

Incorporating Quality Features: The illustration in Fig. 8 is presented to further demonstrate, as in Fig. 2, the possibilities of incorporating quality features other than surface roughness or tolerance. The difference between two curves is method governed by the design of the part. In order to gain the benefit of the low cost "through-feed" method on the centerless grinder, the ground diameter must be the largest dimension on the part. Should such design be impractical, the engineer is guided toward selection of a generous tolerance for the resulting "in-feed" method in order to minimize cost.

Rotary Surface Grinding: The final illustration in the series of simplified cost-comparison charts proposed as cost-control guides is shown in Fig. 9. It covers rotary surface grinding and is presented primarily to demonstrate that not in all cases is cost severely affected by quality variation. Here the full cost increase over the whole tolerance range is 15 per cent and is by far the smallest of all the illustrations. Yet even in this narrow range, more than half the cost increase occurs between the 0.001 and 0.0005-in. tolerances.

These charts by no means demonstrate the total scope of possibilities. More recent studies have shown possibilities in the direction of compounding such comparative data into more comprehensive form, permitting greater selectivity of conditions.

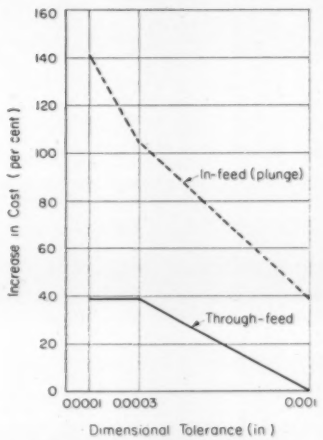

Fig. 8—Costs of centerless grinding based on two methods of feeding parts into the machine.

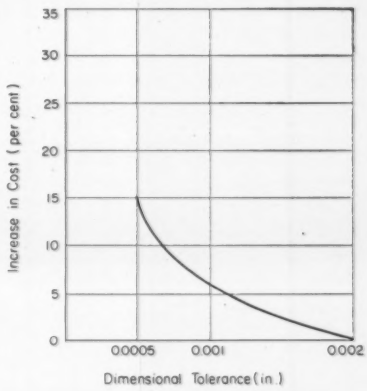

Fig. 9—Effect of dimensional tolerance on cost of rotary surface grinding.

General Application: Since the charts illustrated were tailored to suit the conditions of the plant under study and based on data confined to that plant, the cost-behavior patterns may not wholly or accurately agree with the experience of other plants. Differences in facilities, processing methods and quality range will affect the character of the cost-behavior pattern. Nevertheless, the idea or principle in general is applicable to any manufacturing organization, and adoption merely requires the creation of charts conforming to needs of the plant in question. The ease with which it can be done by any manufacturing organization will be determined by the degree of standardization and availability of corresponding industrial engineering data.

From a paper entitled "Analysis of Manufacturing Costs Relative to Product Design" presented at the ASME Semi-Annual Meeting in Cleveland, June, 1956.

Designing systems for

High-Temperature Hydraulics

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TWO basic approaches can be taken when designing a system for operating in high-temperature environments. One approach would be to use components which are intended for lower-temperature operation and provide enough cooling in the system to insure that the component will not be heated above its operating temperature. The other approach is to design all portions of the system to be compatible with the temperature environment and operate without cooling.

Cooled systems in themselves, can be planned in either of two general ways. The cooling can be by means of a central heat exchanger, or the individual components which are most subject to heating can receive the cooling. The latter technique, which is called peripheral cooling, can utilize water or alcohol sprays or other means of removing heat from the component.

However, cooling devices are often heavy and unreliable. The use of systems and components which are compatible with high temperature usually results in designs which are lighter, simpler and more reliable than if cooling is used.

Fluids: The petroleum-base hy-

draulic fluid MIL-O-5606 will be used in military aircraft at temperatures up to 275 F. Volatility of MIL-O-5606 fluid might be the only characteristic which would limit this fluid in high-temperature use. An excellent set of series of elastomeric seals, the MS28784 and MS28785 seals, are becoming available for use at 275 F.

At temperatures above 275 F, however, the high flammability of MIL-O-5606 fluid and its tendency to form tacky films when exposed to high-temperature air severely limit its potential use.

Synthetics: A whole host of synthetic fluids has been proposed for use as hydraulic fluids at elevated temperatures. Of these, the silicate esters, the diesters, and the silicones have received the greatest attention and evaluation. Of these three types, by far the greatest amount of development has been done with the silicate esters.

Compounded Diesters: The search for a suitable high-temperature lubricant for jet engines has led to the development of compounded diesters. Some high-temperature hydraulic testing has been done with fluids based on the most promising diester, di-2-ethylhexyl-sebacate. The use of these fluids has been limited by the poor high-temperature characteristics of additives and by the lack of an elastomeric seal which was compatible with the fluid at high temperatures. Certain new elastomers, particularly the class known as Poly-FBA elastomers appear to have promise as high-temperature sealants for diesters.

Silicone Fluids: The silicone fluids can be formulated to be quite stable at high temperatures. Best of all, the silicones exhibit a much lower change in viscosity with changes in temperature than any other fluids which are being considered as hydraulic fluids. Unfortunately, the silicones which presently exhibit the best high-temperature characteristics, the methyl silicones, are very poor lubricants for ferrous surfaces. Some recent work with methylphenyl, by-phenyl, and chlorophenyl silicones shows promise of increased lubricity of ferrous surfaces, particularly where the rubbing surfaces are quite hard.

Seals: As the rubber O-ring has received almost universal adoption in the United States as the standard seal for aircraft hydraulic systems, it is to be expected that most seal designs proposed for high-temperature use would be modifications in material or installation, of the elastomeric torus.

Buna N Base O-Rings: The AN series of O-ring seals and gaskets is compounded from a Buna N base and these are intended for use with MIL-O-5606 petroleum-base oil. Some of the AN formulations have shown the ability to withstand higher temperatures. A Military Specification MIL-P-18017 and two sets of drawings, MS28784 and MS28785 have been issued to cover the use of Buna N O-ring seals with MIL-O-5606 oil over the temperature range of −65 to 275 F.

Neoprene Seals: When temperatures in excess of 275 F are to be encountered, the design of the seal must take into account both the working temperature and the chemical nature of the hydraulic fluid. O-rings compounded from Neoprene W and Neoprene WRT base stocks have been shown to have usability at temperatures up to 400 F in silicate-ester fluids. Elastomers of Acrylon EA-5 base stock may allow silicate-ester fluids to operate at temperatures above 400 F and the Poly-FBA stocks may be suitable for both silicate esters and diesters at the high temperatures.

Table 1—Spring Materials for High-Temperature Service*

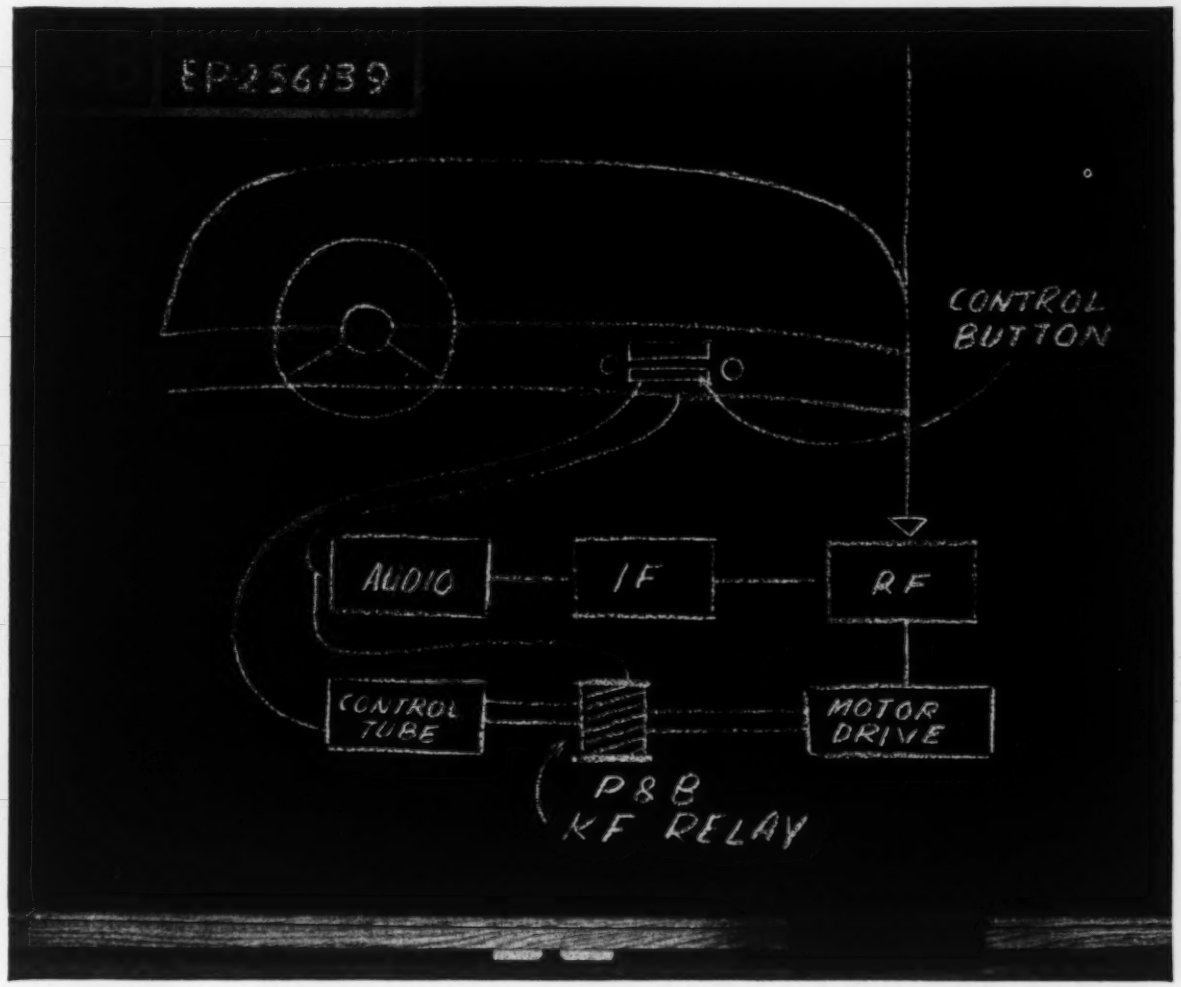
Spring Material	Permissible Temperature (F)
Brass spring wire	150
Phosphor bronze	225
Music wire	250
Beryllium copper	300
Hard-drawn steel wire	325
Carbon spring steels	375
Alloy spring steels	400
Monel	425
K-Monel	450
Z-nickel Type B	500
Stainless steel (18-8)	550
Stainless, chromium Type 431	600
Inconel	700
High-speed steel	775
Inconel-X	850
Chrome-moly-vanadium	900
Cobenium, Elgiloy	1000

*From AE 61-8 Part 2 "Report of the First Services-Industry Conference on High-Temperature Hydraulic Systems," Bureau of Aeronautics, Navy Dept., Washington, D. C., January 26-27, 1954.

Compression Set: All the elastomeric compounds which have shown compatibility with high temperatures in the proposed hydraulic fluids have exhibited pronounced compression set when operated under pressure at high temperature. Apparently, the combination of high pressure and temperature remolds the O-ring to its loaded cross-section configuration. Upon subsequent cooling, the seal does not regain much, if any, of its original round cross section. The presence of this compression set probably accounts for the often-encountered phenomenon of a hydraulic system sealing well at high temperature, leaking upon cooling and again sealing well when the temperature is raised once more.

Backup Rings: At pressures above approximately 1500 psi, non-extrusion backup rings are needed to protect the O-rings. At temperatures in excess of 200 F, backup rings of leather soon char and disintegrate. Teflon backup rings work quite well at temperatures up to approximately 300 F. Above this temperature, the Teflon loses enough rigidity to allow it to flow and slough off under load. This sloughing off of the backup ring can generate contaminant in the system. Eventually, the cross section of the Teflon ring is reduced to a point where the backup ring no longer can protect the O-ring from extrusion. The O-ring then soon fails due to nibbling. Some recent development work has indicated that the use of backup rings made from Teflon which is sintered into a ceramic matrix may provide a real improvement in dimensional stability.

Some experimenters have tried using an O-ring which was backed by a Teflon ring which was, in turn, prevented from flowing by a



P&B relay "controls" signal-seeking radio

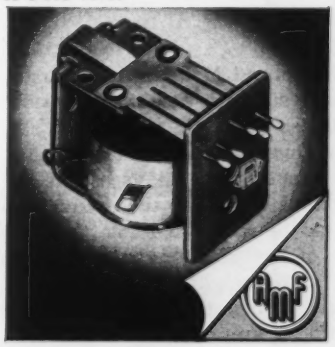
One of the latest and finest car radios actually tunes *itself, automatically.* The user simply presses a special button and the radio "finds" the first signal in the area strong enough for good reception. Another push, the next "listenable" station, wherever the car may be.

The principle of operation is simple. A P&B relay automatically interrupts the current to a tuning motor the moment the incoming signal reaches a usable level.

But the *practice* required a relay that would outlast the busiest station-changer. It had to withstand the vibration of the car, yet work on extremely low and critical drop-out current. It had to be highly compact and *low* in cost. The P&B engineered relay—one of more than 20,000 P&B design variations—was all of these.

Whether your product or problem requires the intelligent application of a standard relay, or the engineering of a special electro-mechanical device, you can be sure P&B will find the answer.

P&B series KF relay with common movable arm, available in Forms 5A, B or C. Unique combination contact and terminal mounted in relay front. Contacts rated 2 amperes. Coil resistance maximum 16,500 ohms. Voltage 6-115 VAC or 6-110 VDC.



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thin brass shim. Another very promising technique is to use spiral metallic backup rings. These dispense with the Teflon stage entirely. It has been found that, with a spiral metallic backup ring which is properly engineered into its housing, the seal will contain pressure until a chemical breakdown of the elastomer occurs.

Springs: One of the most troublesome problems, when adapting component designs for high-temperature use, is acquiring springs which will have the same strength and rate at high temperature as at low and which will not change in preload adjustment while changing in temperature. Commonly used spring materials lose in both strength and modulus of elasticity when subjected to elevated temperatures. In hydraulic-system components this results in variable-displacement pumps not being able to maintain system pressure and relief valves losing their settings.

The solution to this difficulty is to utilize spring materials which are not significantly affected by elevated temperatures. A list of maximum permissible temperatures of spring materials, based on a 5 per cent loss in modulus of elasticity at the elevated temperature, is given in Table 1.

The high-temperature materials all have lower moduli of elasticity and elastic limits than the spring materials used in the −65 to 160 F band. This means that the springs will be larger and more lightly loaded. This additional space occupancy and lowered resistance to a vibrational environment must be considered carefully when designing components for high-temperature service.

Structural Metals: A nondimensional strength-weight comparison between SAE 4130 steel and several aluminum alloys indicates that, at temperatures in excess of approximately 275 F, the use of steel would be more favorable than the use of any of the aluminum alloys on a straight strength-weight basis. When the requirements of stiffness are considered, however, aluminum alloys appear favorable at temperatures well above 275 F. This occurs because a design based on strength alone might yield structural sections which are strong enough but too compliant. The tendency of aluminum alloys to creep and to lose dimensional stability may be as strong a factor in establishing an upper temperature limit for these materials as the strength characteristics.

Hard chromium plating, as used on actuator rods and other smooth surfaces, withstands high oil and ambient temperatures very well. Cadmium plating, however, is quite unsatisfactory.

The most satisfactory, durable protective coating for metals which will be subjected to high oil and ambient temperatures seems to be a chemical nickel plate. Chemical nickel plate, which is also known as electroless nickel, can be applied on any surface which can be wetted in the plating bath. Many surfaces which cannot be plated by electrolytic means are easily finished with electroless nickel.

Filtration: At temperatures above 275 F, the familiar fiber and phenolic filter elements give trouble. The glue which bonds the filter element together loosens and allows unfiltered oil to pass through.

Sintered metallic filters have been used in aircraft and missile installations with great success. With the proper design of housing, these filters can be used at oil temperatures well in excess of 500 F. The completely metallic structure of these filters, particularly when they are fabricated from nonmagnetic materials such as bronze and stainless steel, allows for the easy incorporation of magnetic devices for trapping ferrous particles. Properly designed permanent magnets will entrap many ferrous contaminant particles which are so fine that they are not caught by the sintered filter.

Proper filtration is extremely important in high-temperature hydraulic systems. Because of the severe attrition rates of metals in this service, fluid contaminants are generated in great quantities. Much of these contaminants consists of particulate matter that is much smaller than 10 microns and cannot be caught in the 10-micron filters normally specified in aircraft hydraulic systems. Many of the servo valves that are being used in modern hydraulic control systems have radial clearances in the order of 2 microns.

Electrohydraulic Servo Valves: Electrohydraulic servo valves and other solenoid-operated devices present another high-temperature operating problem which, while not directly hydraulic in nature, is a limiting factor in hydraulic equipment. The mechanical and dielectric strength of most electrical insulating materials fall off quite rapidly at elevated temperatures. This effect is felt because electrical solenoids are, in themselves, heat sources. As the oil and ambient temperatures rise, the heat developed by the I^2R loss in the coil has no place to go until the coil temperature rises sufficiently above the ambient to develop the necessary thermal gradient.

As in the case with back-up rings, the first improvement is the use of Teflon. By substituting Teflon for varnish insulation, the working temperature of solenoids can be raised to approximately 400 F. For operating temperatures in excess of 400 F, the presently best known insulation is glass cloth. Although weak mechanically, glass-cloth insulation should be usable at temperatures well in excess of 1000 F. Unfortunately, the glass-cloth insulation is much more bulky than Teflon or varnish.

Stainless-Steel Tubing and Fittings: Aluminum tubing and fittings have, of course, no place in a 400 F system. For these and higher temperature systems, only stainless-steel tubing and stainless or alloy-steel fittings should be used. Some experimenting has been done with tubing and fittings of titanium but this material does not yet seem ready for hydraulic system use.

From a paper entitled "High-Temperature Aircraft Hydraulics" presented at the ASME Aviation Conference in Los Angeles, March, 1956.

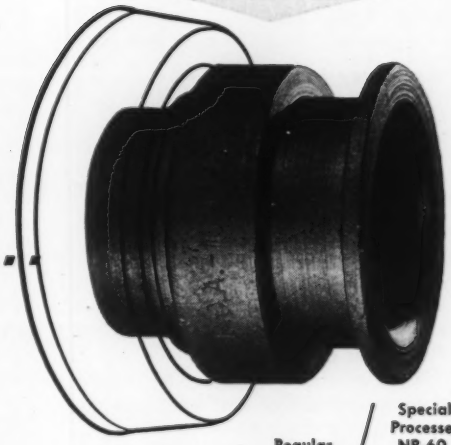
"SWITCH!" said Ostuco

. . . and savings were surprising!

Pleasant surprise, too! Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc. Lancaster, Pa., was machining OSTUCO seamless tubing to make a clutch release bearing collar used as original and replacement equipment. Results were fine!

Then word came from OSTUCO, recommending a switch to OSTUCO's newly developed NP-60, tubing specially processed for machineability. Cost was slightly higher, but BCA and OSTUCO engineers predicted the savings would justify the change.

they switched . . .



. . . and they SAVED!

	Regular	Specially Processed NP-60
Production per 8 hour shift (units)	675	840
Production time per 1000 units (hours) . . .	12.35	10.03
Total Labor per 1000 units (man-hours) . .	13.09	10.63

Besides the savings, Bearings Company of America was pleased with the better finish of the new part. They point out that the collar in photo above "shows the finish as it comes directly off the machine."

It happens this way often enough to warrant checking with OSTUCO about your tubing applications and production problems. Contact your nearest OSTUCO Sales Engineer or write direct to the Shelby factory —there's no obligation!

OSTUCO SHELBY, OHIO

OSTUCO TUBING

SEAMLESS AND ELECTRIC RESISTANCE WELDED STEEL TUBING—Fabricating and Forging

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • **SHELBY, OHIO**
Birthplace of the Seamless Steel Tube Industry in America

SALES OFFICES: BIRMINGHAM • CHARLOTTE • CHICAGO (Oak Park) CLEVELAND • DAYTON • DENVER • DETROIT (Ferndale) HOUSTON • LOS ANGELES (Beverly Hills) • MOLINE NEW YORK • NORTH KANSAS CITY • PHILADELPHIA PITTSBURGH • RICHMOND • ROCHESTER • ST. LOUIS ST. PAUL • SALT LAKE CITY • SEATTLE • TULSA • WICHITA

CANADA, RAILWAY & POWER ENGR. CORP., LTD.

EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY
225 Broadway, New York 7, New York

—ITEM 563—
For More Information Circle Item Number on Yellow Card—page 19

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Solenoid Valves

Latest designs of two, three and four-way solenoid valves are described in condensed catalog No. 201. Presented are engineering information, flow charts, operation and construction details, prices and selection guidance. Engineering data section contains useful formulas and charts on fluid flow and control. 32 pages. Automatic Switch Co.

—Circle ITEM 401

Swivel Joints

Offered in ¼, ⅜, ½ and ¾-in. sizes, single-plane swivel joints are usable for hydraulic and pneumatic service. They provide 360-degree rotation in a single plane to connect fluid lines to rotating elements of machinery and equipment. Specifications of ball and thrust bearing types are given in catalog sheet 406-A. 2 pages. Barco Mfg. Co.

—Circle ITEM 402

Gears, Sprockets, Chain

Specifications for extensive line of spur, internal, miter, bevel, worm and spiral gears; racks; worms; sprockets; chain; pulleys; bearings; universal and flexible joints; pillow blocks; journal boxes; and speed reducers are found in illustrated pocket-size catalog. 118 pages. J. J. Quinn Industries, Inc., Chicago Gear Works Div.

—Circle ITEM 403

Pumps, Cylinders & Valves

Detailed data on oil-hydraulic pumps and motors, cylinders and valves are found in three sections of illustrated catalog H-7. Dimensional and cutaway drawings are incorporated. 20 pages. Commercial Shearing & Stamping Co.

—Circle ITEM 404

Teflon Products

Data on properties, specification table and descriptions of fabricated products made of DuPont Teflon are included in brochure. The John Crane Chemlon products covered include mechanical and hydraulic packings, gaskets, bellows, sheet, rod, tubing, tape, molded and machined parts, and electrical parts. 12 pages. Crane Packing Co.

—Circle ITEM 405

Plastic Pipe, Duct & Valves

Line of corrosion resistant polyethylene and polyvinyl chloride pipe, tubing, ducting, valves and fittings for industrial uses is described and illustrated in catalog. Properties of materials are given. 12 pages. American Agile Corp.

—Circle ITEM 406

Machinery Mounts

Eighteen case histories which are typical of installation problems that prevent full utilization of machine tools for full production are included in illustrated folder "42 Machine Tool Builders Agreed." Barry Mounts described make machines mobile, yet cushion vibration. 8 pages. Barry Controls Inc.

—Circle ITEM 407

Beryllium Copper Alloy

High electrical conductivity, service temperatures of 400° F and above, good spring characteristics and corrosion resistance are design factors for Berylco 10 strip, a beryllium copper alloy, brought forth in illustrated bulletin. Properties and application data are given. 4 pages. Beryllium Corp.

—Circle ITEM 408

Bonding Agent

Properties of one-component epoxy metal bonding agent R-385, described in technical bulletin, include inertness to acids, alkalies, corrosive salt solutions, petroleum solvents, oils and acetones. It is supplied in paste form and is cured by baking 1 hour at 325°F. 4 pages. Carl H. Biggs Co.

—Circle ITEM 409

Electronic Computer

Simplified "short course" in the basic theory and practice of analog computers is found in data file 121. It explores various aspects of simulation and describes its implementation with analog computers for solving wide variety of problems. 4 pages. Beckman Instruments, Inc., Berkeley Div.

—Circle ITEM 410

Molybdenum for Gears

"Moly Steels for Cast Gears" is booklet explaining advantages of molybdenum alloys which permit reduction in size and weight of cast steel gears. Comparative steel tensile strengths are given. 4 pages. Climax Molybdenum Co.

—Circle ITEM 411

Precision Contract Work

Engineering and manufacturing facilities for design and production of precision parts on contract basis are described in bulletin "Your Second Manufacturing Plant." Company makes aircraft components, screw machine parts, cold headed products and precision hardware. 8 pages. Aero Supply Mfg. Co.

—Circle ITEM 412

Voltage Regulators

Two RM (repetitive manufacture) induction voltage regulators which, at lower cost replace nine former station ratings, are subject of illustrated booklet GEA-6386. They provide Class I accuracy as defined by ASA, and will carry increased future loads without change of equipment. 8 pages. General Electric Co.

—Circle ITEM 413

Potting Shells

Various shapes and sizes of potting shells for miniature electrical connectors are illustrated on data sheet. Connectors are sealed against moisture, and cable strain is prevented. 2 pages. DeJur-Amsco Corp.

—Circle ITEM 414

Carbide Tools & Products

Revised "Carmet Catalog" gives detailed information on carbide applications and tools that are available with carbide tips. Data are given on various grades to aid in selection. 32 pages. Allegheny Ludlum Steel Corp.

—Circle ITEM 415

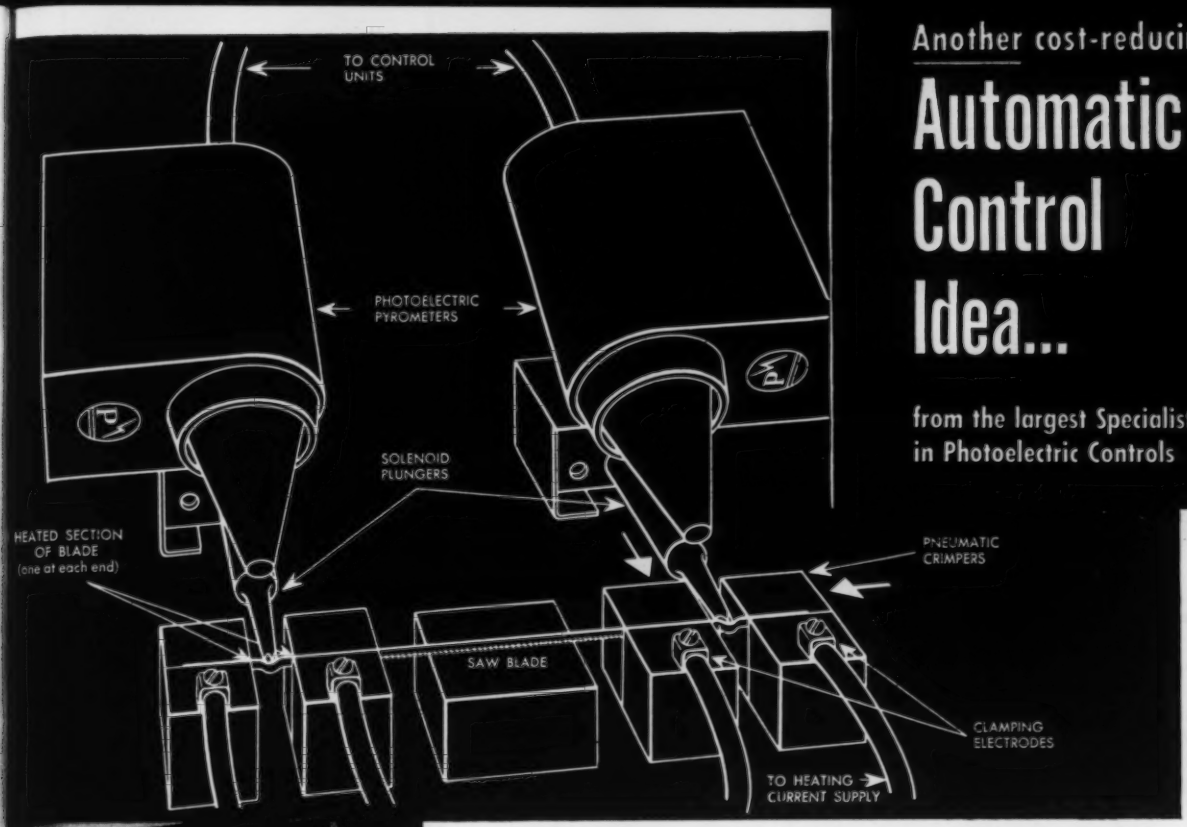
Motor Terminal Boxes

Four basic sizes of motor terminal boxes described in illustrated bulletin

Another cost-reducing

Automatic Control Idea...

from the largest Specialists in Photoelectric Controls



Temperature-Controlled Automatic Forming of Metal Parts

In finishing the narrow blades used in coping saws, each end of the blade is hot-formed into a small loop or "ear" that locks the blade in place on the saw frame. Temperature of the blade ends must be exactly right: too high, and the steel becomes brittle . . . too low, and the loops are difficult to form correctly.

Parker Manufacturing Company, in Worcester, Massachusetts, used two Photoswitch Photoelectric Pyrometers to automate the whole process. The unfinished blade is placed in the forming jig, and an actuating button is pressed. Electrode clamps at each end of the blade press tight, and pass electric current through a small section of the blade itself, so that the tips grow red hot. At exactly the right temperature, each pyrometer automatically trips a plunger mechanism that forms the loop in the metal. The instantaneous response of the pyrometer cuts the heating and forming cycle to less than ¾ of a second.

The results are greatly increased production rate, uniformly high quality, drastic reduction of unit costs, and reliable, self-checking operation that *automatically* takes account of every important variable.

In Photoswitch's wide variety of high quality photoelectric controls, liquid level controls and electronic timers, you will probably find an exact answer to your automation requirements. Write for the helpful new Photoswitch Catalog . . . and if you have a specific problem, tell us about it.

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ITEM 544

MA2 are available with various hole openings to suit individual requirements. Dimensional drawings are included and gaskets are described. 8 pages. Kolton Electric Mfg. Co.

—Circle ITEM 416

Thermistors

Dimensional drawings, physical descriptions and electrical specifications for precision thermistors are contained in illustrated catalog EMC-1. Types offered are beads, rods, disks, washers and built-up assemblies. Electrical characteristics and applications are discussed. 12 pages. Fenwal Electronics, Inc.

—Circle ITEM 417

Powder Metal Products

"E-56 Engineering Manual" contains revised data on properties of Oilite materials and lists Brinell and Rockwell ratings. Covered are self-lubricating bearings, finished machine parts and permanent metal filters. A 12-page insert lists over 1000 standard bearings and cored, solid bar and plate stock. 52 pages. Chrysler Corp., Amplex Div.

—Circle ITEM 418

Self-Locking Fasteners

Complete line of self-locking fasteners, including screws, bolts, set screws, hex nuts, cap nuts, threaded inserts and special fasteners is described in revised catalog 11-B. Fasteners use nylon pellet in threaded area to lock in any position along the thread. Specifications are given. Nylok Corp.

—Circle ITEM 419

Load Cycle Counters

Only work or operations actually performed are counted by Ram load cycle counters, subject of illustrated bulletin. It is applicable wherever there is a change in power used to perform the work cycle. How it works, where it can be used and its features are covered. 4 pages. Ram Meter, Inc.

—Circle ITEM 420

Rolled & Forged Rings

Production of seamless forged and rolled rings is subject of illustrated bulletin. Four-page chart shows, in ⅛-in. increments, the weights for rings from 1 to 145 in. overall diameter. 16 pages. ALCO Products, Inc.

—Circle ITEM 421

Electromechanical Switches

Two general types of electromechanical switches—automatic stepping switches and key switches for manual operation—are described for industrial applications in illustrated bulletin T5001. Stepping types have up to 100 steps and key type is offered in various designs. 12 pages. Stromberg-Carlson Co.

—Circle ITEM 422

Pressure Pickups

Especially suited for measurement and control applications which involve severe vibration, acceleration and ambient temperature variations, type 4-311 pressure pickups are offered in 10 to 5000-psig ranges. Full data on these units are given in bulletin CEC-1539B. 2 pages. Consolidated Electrodynamics Corp.

—Circle ITEM 423

Motors & Drives

Descriptions and full-color illustrations are used to show design and features of open, totally enclosed and explosionproof electric motors; Varidrives; Synchrogears; and right-angle worm gear motorized drives in bulletin 1878. Also detailed are vertical and Verticlosed hollowshaft motors. 8 pages. U. S. Electrical Motors Inc.

—Circle ITEM 424

Nonferrous Forgings

Aluminum, brass and copper forgings produced to meet user's requirements are subject of illustrated booklet "Revere Forgings." Charts enumerate physical, mechanical and fabricating properties of various alloys. Advantages of die-pressed forgings are explained. 12 pages. Revere Copper & Brass Inc., Rome Mfg. Co. Div.

—Circle ITEM 425

Shaft-Precision Encoder

Details of the type 309-13 photoelectric shaft-position encoder are given in bulletin 4605. This unit is a precision analog-to-digital converter for direct reading of shaft positions to an accuracy of 1 part in 8192. It is used in mechanical testing, missile guidance, radar, optical tracking and similar applications. 4 pages. Electronics Corp. of America.

—Circle ITEM 426

Hydraulic Pumps & Motors

Performance and application data on a complete line of positive-displacement gear type pumps and motors are contained in illustrated bulletin H3A1. Usable with noncorrosive liquids with lubricating qualities, pumps have capacities ranging from 1/5 to 30 gpm. Pressures range to 1500 psi. 12 pages. Webster Electric.

—Circle ITEM 427

Drawing & Drafting Supplies

Drawing sets, drafting instruments, design aids, drafting materials and measuring aids are described in 1956 Catalog E. Equipment, materials and supplies are expressly designed for use by engineers and designers. 84 pages. Alvin & Co.

—Circle ITEM 428

Marine Propulsion Gearing

The application of various types of marine propulsion gear units to diesel, electric or engine service is covered in bulletin AD 3761. Graphs, tables and drawings give capacities and design data. 8 pages. Westinghouse Electric Corp.

—Circle ITEM 429

Tap Guide Wall Chart

Twelve comprehensive quick-reference tables arranged for wall mounting comprise the "Tap Guide Wall Chart." Included are tap pitch tolerances compared with NSTC and Unified Thread Class Fits 0-80 through 1½-12, tap drill sizes from 0-80 through 1-27 with basic thread dimensions, suggested tapping speeds, lubricants for tapping various metals, rake angles, decimal equivalents and tap terminology. Wood & Spencer Co.

—Circle ITEM 430

Miniature Electric Connectors

Miniature, printed circuit, rectangular, high voltage, rapid-disconnect panel type, pressurized and hexagon connectors for electrical and electronic equipment in land, sea and air use are detailed in illustrated bulletin. 4 pages. Gorn Electric Co.

—Circle ITEM 431

Finned Tubing

"Opportunities Unlimited — Using Wolverine Trufin" booklet explains potential applications of integrally finned tube in processing, electrical, water heater, refrigeration and allied industries. Calumet & Hecla, Inc., Wolverine Tube Div.

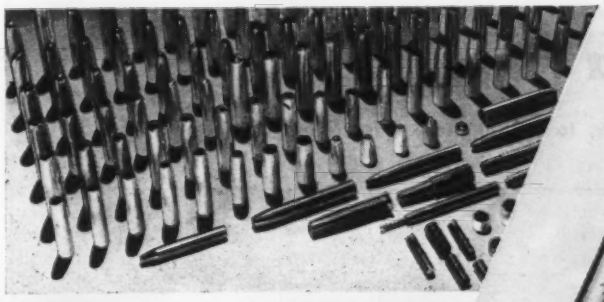
—Circle ITEM 432

Rivets & Riveting Machines

The advantages of riveting in parts design as well as specifications of standard and special rivets are content of bulletin 7/Th. Also described are various sizes of floor and bench riveting machines. 8 pages. Judson L. Thomson Mfg. Co.

—Circle ITEM 433

Deep Drawn Metal Parts



- SHELLS
- CANS
- CUPS
- FERRULES
- SPECIAL DRAWN SHAPES

Parker "Jotter"* ink cartridge fully drawn on one machine for maximum economy

● Secret behind the greater writing capacity of the Parker Pen Company "Jotter" ball point is this unique, king-size ink cartridge measuring $3\frac{5}{16}''$ in depth.

Most part makers would have to produce this cartridge in stages, accomplishing a partial draw on one machine and completing it on another. Extra annealing and superfluous material handling introduce greater costs.

Sylvania has, at its Connecticut plant, multiple-plunger equipment to produce this complete draw in one continuous operation, on one machine, *at a saving to the customer.*

Sylvania's Parts Division offers you facilities for all eyelet and special formed parts—backed by 23 years' experience in helping manufacturers reduce their parts costs.

High-speed, multiple-plunger eyelet machines range in capacity from the smallest eyelet to a 3-ounce can drawn from a 5″ blank. Parts may be drawn in all materials ranging in thickness from 0.007″ to 0.055″. The Metal Stamping section of Sylvania's 4-way parts service is also equipped with four-slides, vertical presses, and special Sylvania-designed equipment to meet all your requirements for small to medium size precision stampings, and wire and ribbon forms. Write for complete information.

*Registered Trade-Mark of the Parker Pen Company

PARTS DIVISION

metal stamping | special wire | molded plastic | electronic parts

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SYLVANIA ELECTRIC PRODUCTS, INC.
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—ITEM 565—

For More Information Circle Item Number on Yellow Card—page 19

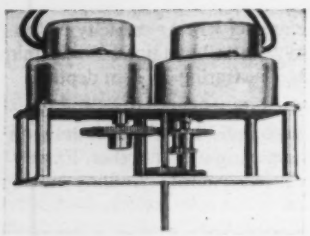
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Drive Unit

uses motors plus differential for three-speed output

Dual-Speed drive unit, series 100, connects two motors and a differential so that speed of the output shaft will be the sum of the two motor speeds. When motors are of different rated speeds, electrical switching gives a choice of three output-shaft speeds. Unit is



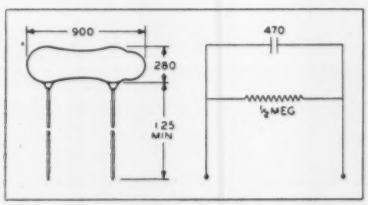
also available with reversible motors, in which case three speeds in each direction are provided. Output speeds range from 180 rpm down to as low as 1 revolution per month. Applications include use as chart drive, control devices in which a fast or a slow speed drive is required, and timers. **Vocaline Co. of America Inc.**, Bristol Motor Div., Old Saybrook, Conn.

—Circle ITEM 451

Resistor-Capacitor

miniature component combines two units in same shell

This single unit resistor-capacitor, requiring the space of a tubular capacitor alone, incorporates a standard CC32 tubular ceramic capacitor connected in parallel to a ceramic base resistor. It is designed for high performance where space is at a premium. Maximum length of the Tube-R-Cap is 0.900-



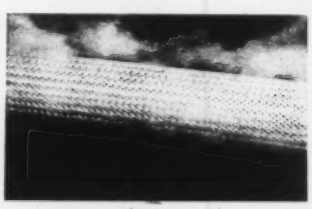
in., diameter is approximately 0.280-in. Rating is 470 mmf, GMV-1500 v ac; resistance is ½ megohm nominal, ½ w. Ceramic body is moisture proof, is unaffected by heat, vibration or common acids. **Globe-Union Inc.**, Centralab Div., 900 E. Keefe Ave., Milwaukee 1, Wis.

—Circle ITEM 452

Porous Glass-Fiber Tubing

epoxy impregnated material has controlled porosity

Called Poro-Tube, glass-fiber epoxy tubing offers controlled porosity through variations in glass-fiber weave, epoxy formula, and impregnation process. Ap-

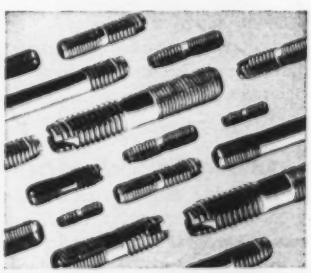


plicable as a replacement for metal Class H motor housings, it simplifies potting, eliminates machining, reduces weight. Additional applications include use as low cost forms for potting and impregnating coils, resistors, and terminal boards, as reusable filters where corrosion resistance is critical, as anodizing and electroplating fixtures where free flow of current and liquid solution is required. Available in a wide range of diameters down to 0.062-in. ID, tubing has temperature resistance to 350 F. Cross sections can be round, square, oval, or triangular; wall thicknesses range down to 0.005-in. Weighing 0.03 lb per cu in., it is impervious to most gases, fuels, oils and chemicals. **Lamtex Industries Inc.**, 51 State St., Westbury, L. I., N. Y.

—Circle ITEM 453

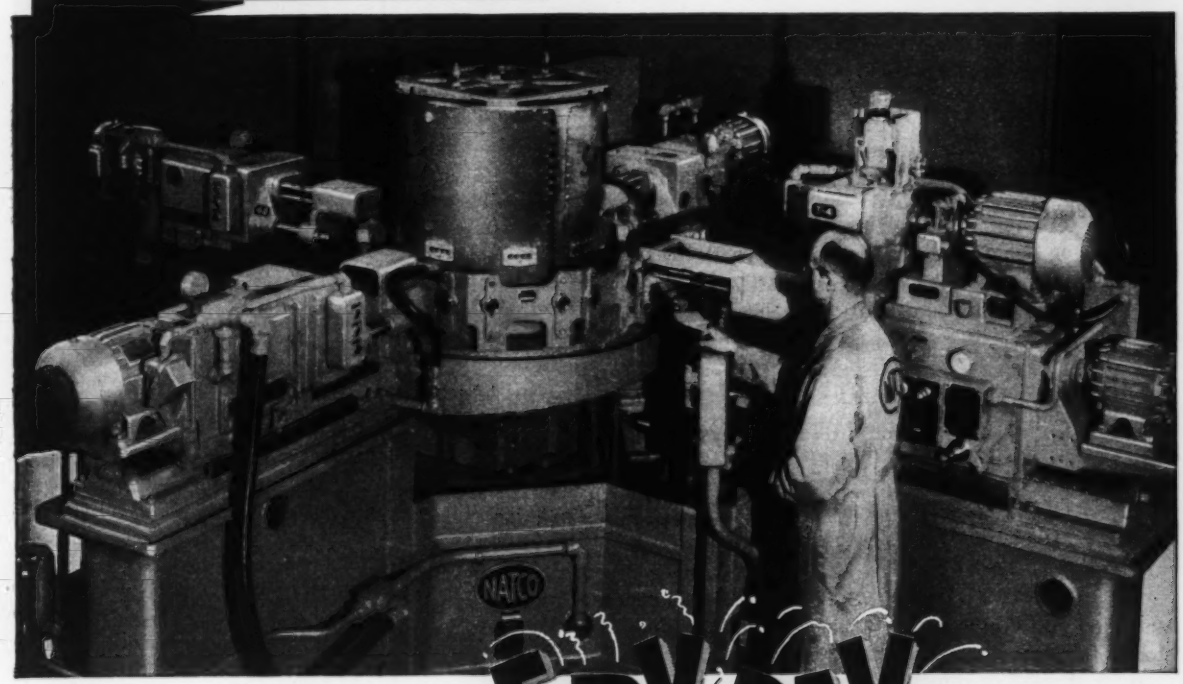
Double-Ended Studs

cut own threads, are self-locking



Tapping, driving and locking are completed in one fast operation with these double-ended studs that cut their own threads. Studs are reusable and require no special adapters or attachments. They can be removed from the hole without thread damage, and then can be redriven in any drilled or tapped hole of the same size. Hole tolerance is not critical, and no special hole preparation is needed. Rolled threads at each end are supplied in any desired style, and slotted end permits hopperizing for automatic feeding and driving. Studs are carburized alloy steel, and are suitable for driving in steel, cast iron, aluminum, magnesium and plastics. Diameters range from No. 4 through 1 in. in

There's **MORE** Cooling Surface in these deep-ribbed **MOTORS**



No Day is FRYDAY with these Allis-Chalmers MOTORS

● Frying of insulation is impossible under normal conditions with the extra-large cooling surface of Allis-Chalmers rib-type TEFC motors. The result — longer motor life assures you "repeat" business from your customers.

LIVE BETTER ELECTRICALLY

The engineered partner of A-C motors is Allis-Chalmers control.

Get Complete Information

To get the most from machinery you build, specify Allis-Chalmers components. Discuss your particular application with your nearby A-C district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5032

—ITEM 566—

any required length. They also can be supplied in high-temperature steel, stainless steel or nonferrous metal. Finishes are plain, Parkerized or plated with cadmium, zinc, brass, bronze, etc. **Pheoll Mfg. Co.**, 5720 Roosevelt Rd., Chicago 50, Ill.

—Circle ITEM 454

Brass Needle Valve

for air or liquid applications to 600 psi

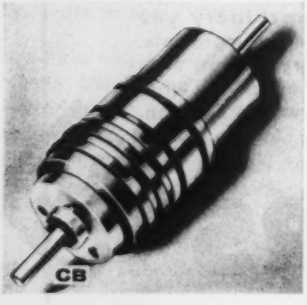
Machined entirely from brass bar stock, this needle valve can be used for shut-off or throttling service at line pressures up to 600 psi. Taper metal-to-metal seat between bonnet and body eliminates packing. Measuring 1⅝ in. overall length, valves are available from stock in all combinations of ⅛ and ¼-in. male and female pipe ports and in ⅜-in. male pipe ports. **Generant Engineering Co.**, 260 S. 20th St., Newark, N. J.

—Circle ITEM 455

Clutches and Brakes

miniature electrical units have no sliding parts

Available in five styles and six sizes, Simplatrol electric clutches and brakes are single-friction types with no sliding parts. Only moving part is the diaphragm which is electromagnetically moved through a short stroke for extremely rapid engagement and disengagement. Clutching and braking are nearly instantaneous, and can be either "soft" or "harsh" as required. Five standard units are: clutch coupling, type K; electric clutch, type C; simple electric brake, type B; combination electric clutch and brake, type CB; and duplex clutch, type D. Diameter of units ranges from ⅞ to 3⅜ in. Input is 6, 12 or 24 v. **Simplatrol Products Corp.**, 24 Salisbury St., Worcester, Mass.



—Circle ITEM 456

Pulleys and Belts

are precision components

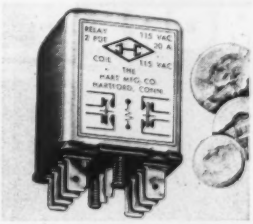
Stainless steel precision pulleys are available from stock in three basic shaft sizes: ⅛, 3/16 and ¼-in.; outside diameters range from ½ to 2 in. Belts are type AF, neoprene or cotton braided. **PIC Design Corp.**, 160 Atlantic Ave., Lynbrook, L. I., N. Y.

—Circle ITEM 457

Heavy-Duty Relays

are compact, have high current rating

High capacity and small size of these Series W general-purpose, heavy-duty relays suit them for use in motor starting systems, solenoid valve controls, heater-circuit controls and similar applications in automation and appliances. Measuring 1½ x 1½ x 1⅞ in. (excluding terminals), they carry resistive loads up to 25 amp at 115-220 v, ac. Contact type is 2, form Z, double pole, double throw, double break. Coils are available for any standard ac or dc input. Breakdown voltage exceeds 1500 v rms. Vibration resistance ranges from 10 to 55 cps with 1/16-in. total excursion. Side and panel mounting arrangements



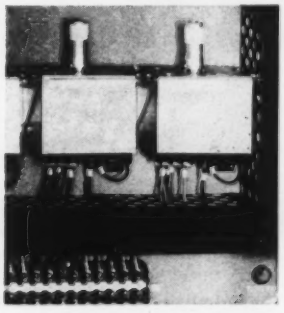
are standard; other mounting arrangements can be supplied on request. **Hart Mfg. Co.**, 110 Bartholomew Ave., Hartford, Conn.

—Circle ITEM 458

Glass-Plastic Channel Duct

allows substitution of flexible for solid-wire layouts

Substantial savings in wiring time and cost in layout of complex wiring patterns are offered by Glastic Channel Duct. Allowing replacement of hand-formed solid-wire harnesses by flexible wiring, the channel simplifies assembly and wiring techniques, allows layout changes at will, and simplifies maintenance. Dielectric and flame-resistance properties are excellent; warpage during and after assembly is negligible. **Glastic Corp.**, 4321 Glenridge Rd., Cleveland 21, O.



—Circle ITEM 459

Liquid Level Control

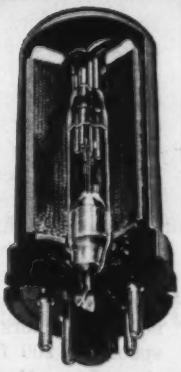
electromagnetic unit has conductivity adjustment

No moving tank parts, floats or stuffing boxes are employed in type 10CB4 electromagnetic liquid level control. For control of all electrically conductive liquids, the unit provides four different resistivity ranges for the probe circuit to match conductivity of the liquid

It can cost you much more to settle for less than this Clare relay

This ad was all but written by a Clare customer. Here is the story as he told it:

"I shopped around for relays for continuous-duty, high-speed switching service. Clare engineers recommended Type HG Mercury-Wetted Contact Relays. They said they were ideal for this application. I thought so, too; but they do cost a little more than some other relays, and I thought I couldn't afford to use them. I thought the extra cost, multiplied by the large number of relays in my machine, would run my price too high. So I built a model with cheaper relays. In just a few weeks the relays wore out. I knew that Clare Type HG relays would last for years under the same conditions, and it didn't take me long then to decide that *I couldn't afford not to use them.*"



Ask yourself whether you, too, don't have jobs for which no other relay is good enough. Consider that the life of a Clare Mercury-Wetted Contact Relay is measured in billions of maintenance-free operations. Compare the cost per flawless operation with that of other relays: this is the crux of the matter—a vital, basic point.

The price is very reasonable, and delivery is quick—one to seven weeks, depending on the particular assembly desired and the size of the order.

FOR COMPLETE INFORMATION on CLARE Mercury-Wetted Contact Relays for single or multiple circuits contact your nearest CLARE representative or address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare & Co., 659 Bayview Avenue, Toronto 17. Cable address: CLARELAY.

Send for CLARE Sales Engineering Bulletins Nos. 120 and 122

CLARE RELAYS

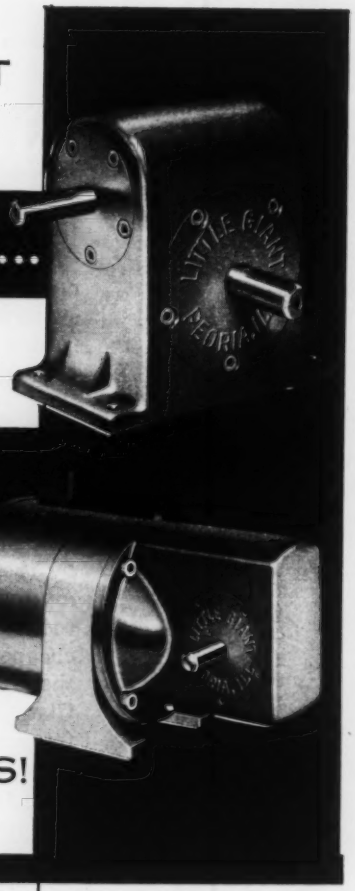
FIRST in the industrial field.

—ITEM 567—

LITTLE GIANT

Speed Reducers...

Gearmotors...



DESIGNED FOR YOUR SPECIFIC NEEDS!

You furnish the specifications—Little Giant engineers will custom-design power transmission equipment to match the application.

Basic components are work-proven standard parts for reduced costs, while housings, mountings, shaft positions and other features are engineered for your specific needs.

There's no cost, no obligation, for this personalized design service. Just submit details of your needs, we will do the rest.

CHECK THESE LITTLE GIANT FEATURES

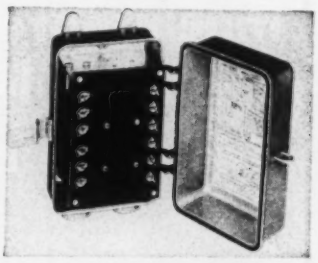
- Worm integral with input shaft. Worm thread and all diameters hardened and ground from alloy steel.
- Bearings and shafts designed for high overhung loads.
- High efficiencies through use of ground alloy worm and 3½% nickel bronze gear.
- Clean, compact design.
- Speed Reducer ratios: 5-4/5:1 to 100:1 within a 1⅓" to 2⅛" center range.
- Gearmotors ratings: 1/50 to 1 H.P.

LITTLE GIANT
PRODUCTS, INC.
1530-50 NORTH ADAMS ST.
PEORIA 3, ILLINOIS

Manufacturers of quality products since 1918

—ITEM 568—

New Parts



being controlled. It can be used for single-level indication or alarm, or pump-up or pump-down control. Input is 115/230 v, 25/60 cycles ac. Low voltage in the probe circuit insures complete safety and eliminates electrolysis. Control relay is rated at 10 amp at 115 v, 5 amp at 230 v, and is designed for motor starter, motorized, or solenoid valve operation. **Electronics Corp. of America,** Photoswitch Div., 77 Broadway, Cambridge 42, Mass.

—Circle ITEM 460

Teflon Sleeving

insulating spaghetti stands high, low temperatures

Kelon-T (Teflon) electrical spaghetti sleeving insulation is unaffected by wide ranges of ambient temperatures, pressure altitudes and humidity. Remaining serviceable at temperatures from −90 to 250 C, it has a good dielectric constant and constant power factor over a wide frequency range. Applications include sheathing for hook-up wire, insulation for solder junctions or use as instrument tubing. It is available in a variety of standard colors, in cut lengths or spools of 200 ft or longer and in sizes from No. 26 to No. 8 and larger. Special sizes are available on order. **Shamban Engineering Co.,** 11617 W. Jefferson Blvd., Culver City, Calif.

—Circle ITEM 461

Tube-Piercing Valve

can be installed without releasing line pressure

Mountable in any position on copper, aluminum, or thin-wall brass tubing, HP-68 piercing valve accommodates ⅜, 7/16 and ½-in. OD tubing. Application is for

TORRINGTON BEARINGS

Heat treating makes the difference!

At Torrington we're as fussy with heat treating a bearing as an expert chef is about a charcoal-broiled tenderloin. No wonder TORRINGTON BEARINGS last long and give dependable service wherever they are used.

For out of TORRINGTON's advanced heat-treating facilities come races and rollers that are consistently hard . . . stable . . . uniform. Quality of steel is important and that's carefully controlled, too. Only the finest bearing quality steels—case-hardening or through-hardening grades—are used in manufacture.

At the Bantam Bearings Division, we make all types of bearings for heavy duty application—Spherical Roller, Tapered and Cylindrical Roller, Heavy Duty Needle, Ball and various types of thrust bearings.

Make sure you specify TORRINGTON. Our many basic types of anti-friction bearings are backed by custom engineering to meet your speed and load requirements. For special jobs, your TORRINGTON engineer will be happy to select or help design the best bearing for you. Call him today!

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY

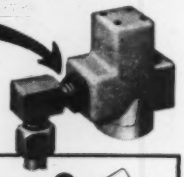
TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

—ITEM 569—

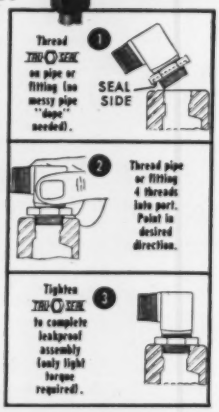
TRU-O-SEAL
TEFLON SEAL
PAT. PENDING

STOPS PIPE THREAD LEAKS instantly!



Prevents future leaks!

TRU-O-SEAL does away with messy pipe "dope" compounds, eliminates damage caused by overtightening of conventional leaky joints, and is immune to ALL known hydraulic fluids and to steam, air, water, solvents, and practically all gases and chemicals. It withstands temperatures from —100° F. to plus 500° F., saves cost and labor of special or welded fittings, and has been fully field tested and proven by leading manufacturers. Comes in ⅛" to 2½" pipe thread sizes.


1
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

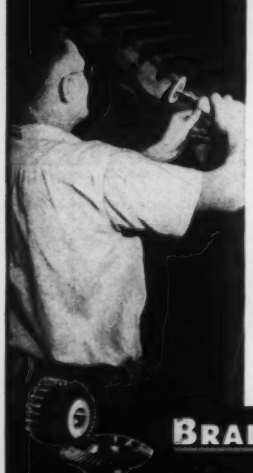
Write for data and prices

TRU-O-SEAL DIVISION
Flick Reedy Corporation
2006 N. Hawthorne Melrose Park, Ill.
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.

—ITEM 570—

Another of the Reasons Behind Brad Foote Quality—

DEBURRING



• Deburring of gears isn't normally included in specs or drawings. And we don't get paid for it. But here at BRAD FOOTE we take pains and expend many man hours on deburring—for we know that one tiny burr can ruin a $100,000 machine.

• Examine your next shipment of gears. See whether your present supplier is painstakingly removing all the burrs. Find out how many hours your assembly department has had to charge against deburring. See another way in which BRAD FOOTE quality and extra attention to details saves you money.

• Prove to yourself the savings that BRAD FOOTE quality can mean. Let us quote on the gear requirements for your next program—whether it be radar equipment, diesel engines, etc. BRAD FOOTE has experience in providing gears for almost every specialized application and would welcome the opportunity of discussing your gear problems.

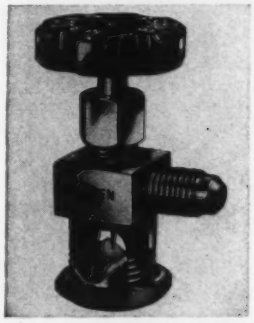
BRAD FOOTE MAKES ALL TYPES OF GEARS— IN A COMPLETE RANGE OF STYLES AND SIZES

BRAD FOOTE GEAR WORKS, INC.
1309 South Cicero Avenue • Cicero 50, Illinois
Bishop 2-1070 • OLympic 2-7700 • TWX CIC-2856-U

subsidiaries
AMERICAN GEAR & MFG. CO. Lemont, Illinois Phone Lemont 920
PITTSBURGH GEAR COMPANY Phone SPalding 1-4800 Pittsburgh 25, Penn.

—ITEM 571—

New Parts



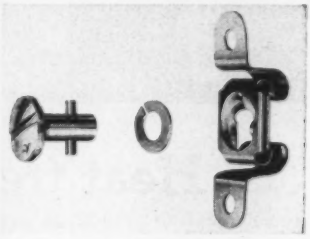
bleed-off of small quantities of water, gas or air conveyed through nonferrous tubing. Valve can be easily installed on lines under pressure without the use of special tools. Water flow capacity at pressure drops from 5 to 30 psi varies from 12.6 to 40.8 gph. Companion valve for smaller tubing can also be supplied. **Madden Brass Products Co.**, Aurora, Ill.

—Circle ITEM 462

Fastener

for thin materials and miniaturized equipment

Designed for use in airborne electronics equipment and small electro-mechanical and computing devices, Camloc 5F fastener is a quarter-turn unit particularly adaptable



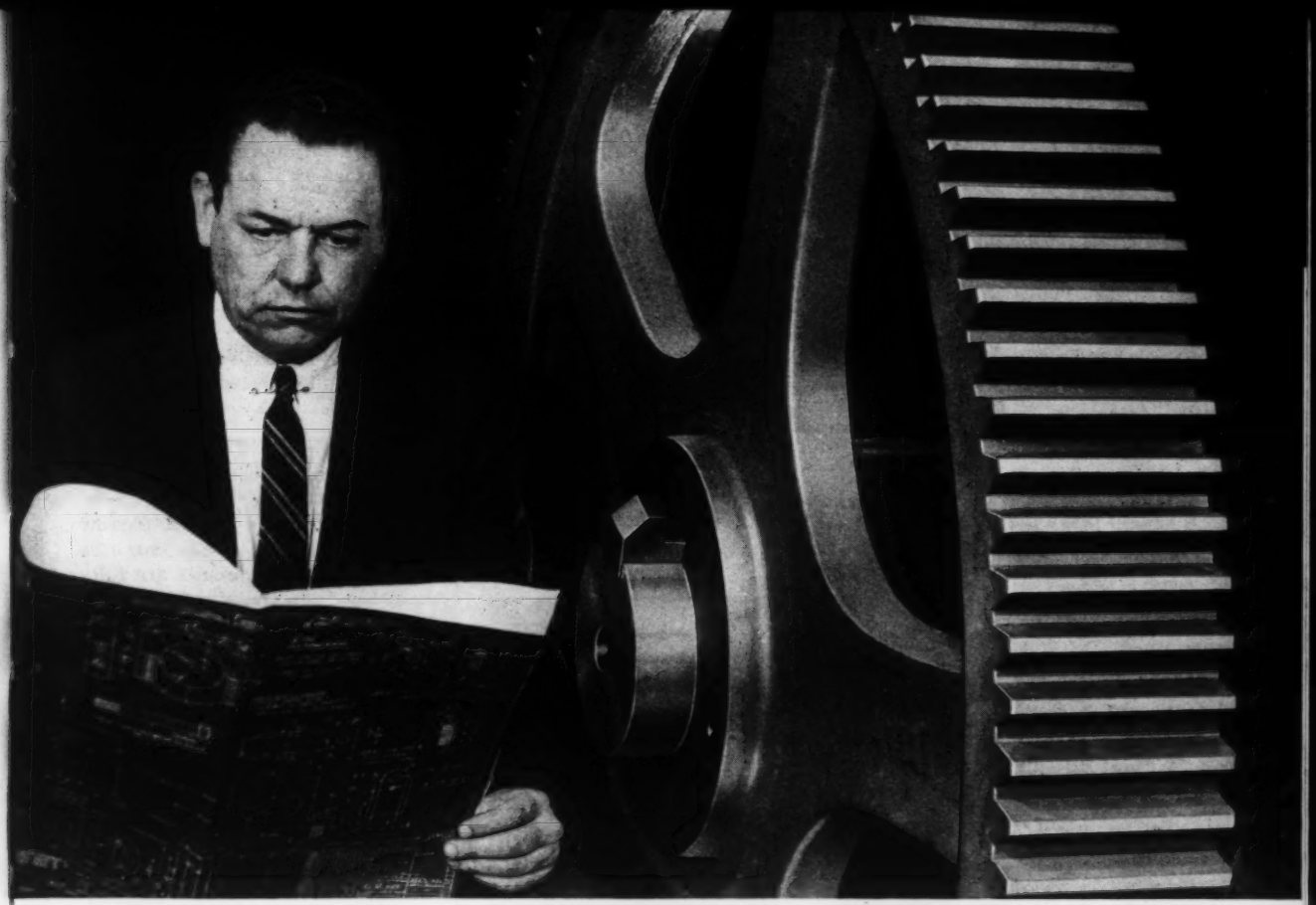
to thin materials. With high strength to weight ratio, it is offered in a variety of head styles. **Camloc Fastener Corp.**, 37 Spring Valley Rd., Paramus, N. J.

—Circle ITEM 463

Miniature Indicator Light

for transistor flip-flop or vacuum-tube circuits

For use in computers and other transistor switching circuits, this miniature indicator light incorporates a biasing-limiting resistor



The gears in an automatic nut former have to be tough and strong to withstand heavy, varying loads. Yet, the castings from which they're made should be easy to machine. That's why this gear for a Waterbury Farrel Automatic Nut Former is made from ASTM-50 gray iron with a nominal composition of 1% nickel and .50% molybdenum.

Moly gives cast iron gears higher strength with toughness and good machinability

"To insure a tough, easily machined gray iron for the gears in our Automatic Nut Formers," says Henry C. Griggs, Metallurgist for Waterbury Farrel Foundry & Machine Co., "we specify .50% molybdenum in our ASTM-50 material. The properties of this material contribute importantly to the reputation of Waterbury equipment for accuracy and high speed production under severe operating conditions."

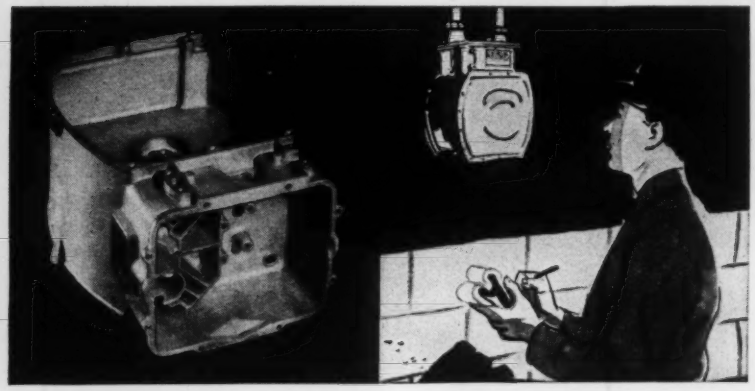
Molybdenum helps to give reliable and reproducible castings – very important factors in consistent performance of gears.

Investigate moly irons. They may be the key to better performance in many of your gear applications.

For the first two in a series of bulletins, "Why Moly Iron," or for technical assistance, write Climax Molybdenum Co., Department 11, New York 36, N. Y.

CLIMAX MOLYBDENUM

—ITEM 572—



The Meter Reader and the Motorist

Thompson Light Metal Castings and Impact Extrusions Serve All Industry

THE meter reader checking on gas consumption and the motorist patiently waiting for traffic to move have one thing in common—both *can count on Thompson.* The meter reader's dials and the motorist's automobile are each improved by Thompson's versatile Light Metals Division.

In the case of the meter reader, it's the housing that's produced by Thompson—with the automobile it's one of many parts, including the torque converter stator for the automatic transmission.

Gas meter housings and torque converters are but two of the many light, strong, durable castings designed, developed and manufactured by Thompson for a diversified list of customer uses. Today Thompson is producing light metal castings for such products as buses and garbage disposers; washing machines and jet planes; automobiles and industrial engines; ice scoops and aircraft engines.

Regardless of your product, if you use castings or impact extrusions, Thompson's creative engineers will gladly show you where and how you can simplify your operations and save on costs with Thompson Light Metals Castings.

We want to quote on your plans and specifications. Write, wire or phone Dept. MD-8, Light Metals Division, Thompson Products, Inc., 2269 Ashland Road, Cleveland 3, Ohio, HEnderson 1-6765.

You can count on

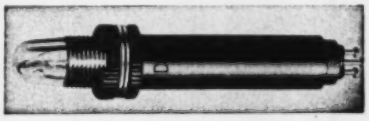
Thompson Products

LIGHT METALS DIVISION

2269 Ashland Rd. • Cleveland 3, Ohio

New Parts

network within its ⅜-in. diam case. Bias voltage is adjusted to a point at which transistor gains control to switch the light on or off. Neon lamp is preaged and selected for a specified operating



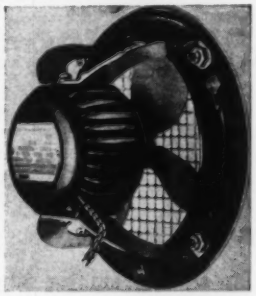
voltage range. The lamp may also be used in conventional vacuum tube circuits where the control signal swings over a narrow voltage range. Overall length is 2½ in.; electrical circuits are fully insulated from the aluminum case. Lenses are clear, red, or amber plastic. **Eldema Corp.,** 9844 Remer St., El Monte, Calif.

—Circle ITEM 464

Venturi-Mounted Fan

is available with 22 different drive motors

Model DFE 4-in. diam propeller fan combines a diecast venturi-type mounting ring, four-legged mounting spider and a separable ring-mounted screen or finger



guard. The venturi ring makes an airtight seal with the mounting surface and provides two alternative directions of air flow. Mounting spider grips the motor at the center of gravity and draws heat effectively from two flats on the finned, diecast motor case. Motor is held steady under conditions of shock and vibration. The fan is available with a choice of 22 different drive motors covering 50 to 1000 cps line frequency, one and three-phase operation and many voltages. Special airborne motors give constant cooling effects at

DU PONT
REG. U.S. PAT. OFF.

PROPERTY AND APPLICATION DATA
ON THESE VERSATILE ENGINEERING MATERIALS
"ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NEWS

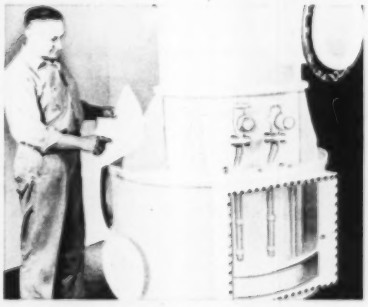
Moving parts made of ZYTEL® nylon resin are economical and durable

Du Pont ALATHON® provides long life for scrubber handling hydrofluoric acid

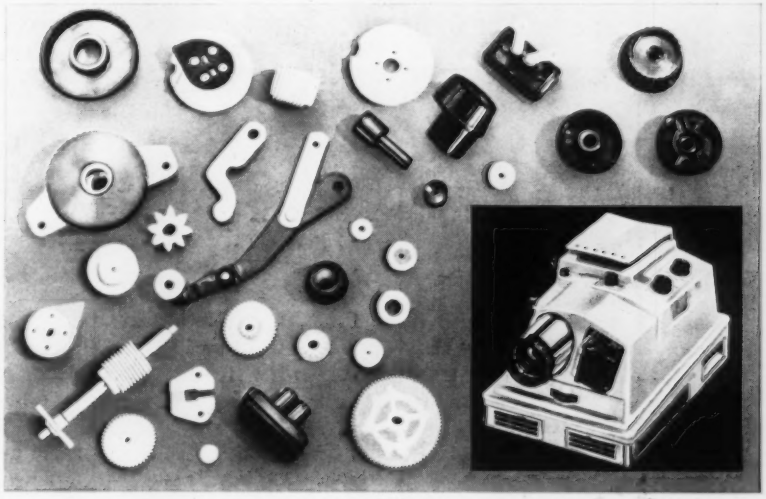
THE EXCELLENT chemical resistance, high impact strength, and the low-temperature flexibility of Du Pont ALATHON polyethylene resin make it an outstanding material for use in many types of chemical processing equipment.

The chemical scrubber shown below, fabricated of Du Pont ALATHON polyethylene resin, is virtually maintenance free. It measures four feet in diameter, is five feet high, and has a gas flow of 2500 cfm at 1½" psi. This scrubber is used in contact with hydrofluoric acid and fluorides.

ALATHON polyethylene resin withstands these corrosive conditions. It is light in weight, nontoxic, and virtually odorless and tasteless. Low temperatures will not affect the strength and flexibility of ALATHON. For more information on this material, clip the coupon.



Manufactured by American Agile Corporation, Cleveland, Ohio, this chemical scrubber is used in contact with hydrofluoric acid, and fluorides.



The "888", a new slide-film projector manufactured by the Revere Camera Company, Chicago, Illinois, features automatic operation. Thirty-one parts made of Du Pont ZYTEL nylon resin are used in the construction of this quality projector.

THIRTY-ONE parts made of Du Pont ZYTEL nylon resin are used in a new 35mm slide-film projector, the "888", manufactured by the Revere Camera Company. A new model Revere automatic slide projector, the "888-D", utilizes parts of ZYTEL also, and features a preconditioning chamber, illumination coverage for 1½" x 1½" transparencies, and coated optics throughout. Because ZYTEL is specified, the intricately shaped precision parts are mass-produced by the injection-molding process. Such molded parts generally require no finishing. Substantial savings in production costs result. Parts of ZYTEL are long wearing and durable. The low coefficient of friction of ZYTEL provides smooth operation and often eliminates the need for lubricants.

Useful combination of properties

Because of its useful combination of properties, ZYTEL nylon resin is used for many types of mechanical parts—bushings and bearings, gears, cams, rollers, worm gears, for example. Parts made of ZYTEL have outstanding toughness, abrasion-resistance, strength in thin sections, lightness in weight, and chemical resistance. ZYTEL nylon resin is a versatile material which design engineers find helpful in solving many of their problems.

Get more information

For more information on how you may incorporate ZYTEL in your own product, mail the coupon on the reverse side.

OVER

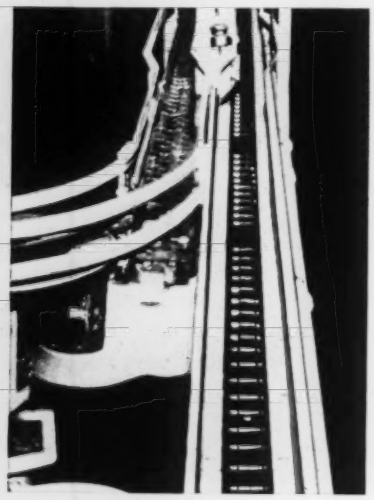
DU PONT
REG. U. S. PAT. OFF.

PROPERTY AND APPLICATION DATA
ON THESE VERSATILE ENGINEERING MATERIALS
"ZYTEL," "ALATHON," "TEFLON," "LUCITE."

PRODUCTS FOR INDUSTRY NEWS

Conveyor wear strips of ZYTEL® nylon resin require no lubrication

A COMBINATION of impact resistance, toughness, resilience, and excellent bearing characteristics makes Du Pont ZYTEL nylon resin



an outstanding material for use in demanding mechanical applications.

The Peter Hand Brewery Company of Chicago has solved several difficult bottling problems by installing conveyor line wear strips made of ZYTEL. Because of the low coefficient of friction of ZYTEL, these wear strips are not lubricated. Wear strips made of ZYTEL give smoother performance with reduced power requirements, effecting start-up of a full line without danger of spilled containers. Neither steam sterilization nor long wear has impaired the efficiency of wear strips made of ZYTEL. Easily installed over existing conveyor ways, wear strips made of ZYTEL can be used with chains of ZYTEL or metal. (*"Nylite" wear strips manufactured by Fenco, Inc., Chicago, Illinois.*)

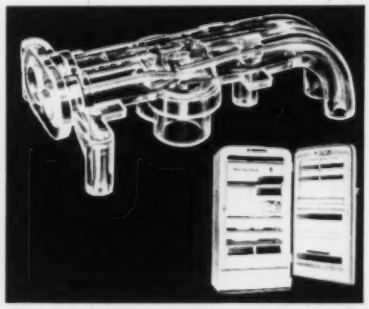
For full property and application data on ZYTEL nylon resin, use the coupon.

Complex venturi valve molded of sparkling, durable LUCITE®

THE HEART of the automatic twin juice fountain is a dual venturi valve, developed and manufactured by The Dole Valve Company of Chicago. The venturi, made of Du Pont LUCITE, operates on water pressures from 15 to 125 pounds, drawing just the right amount of concentrated fruit juice to provide the correct 3 to 1 mixture, blended and aerated.

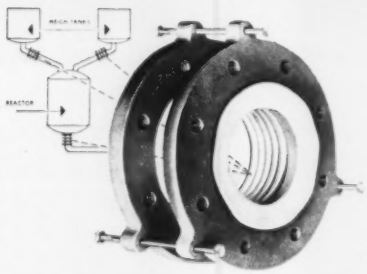
LUCITE acrylic resin was selected for this application because of its moldability, and resistance to corrosion by fruit acids. Had this complicated valve been produced in metal, it would have required many costly machining and assembly operations. With LUCITE, the entire unit is produced in a single operation, affecting a substantial reduction in cost of production for this part. The transparency of LUCITE makes it easy to keep the spout clean.

LUCITE may offer many design advantages in certain of your industrial applications, especially where visibility is important. Its transparency, strength, impact resistance and moldability make LUCITE suitable for rugged applications.



Twin juice fountain of LUCITE mixes and dispenses fruit juices as needed. Complex unit is injection molded in a single operation by Chicago Molded Products Corporation, Chicago, Ill., for The Dole Valve Co.

Send for further property and application data on LUCITE. See how LUCITE can provide the answer to your next design problem.



Expansion joint bellows of TEFLON® tetrafluoroethylene resin is flexible, yet strong. Its flexibility compensates for misalignment between connections in pipes joining tanks, pumps, or reactors . . . absorbs vibration and allows equipment parts to expand and contract safely. TEFLON has a service temperature ranging from −450 F. to 500 F.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 128, Du Pont Building, Wilmington 98, Delaware.
In Canada: Du Pont Company of Canada, Ltd., P. O. Box 660, Montreal, Quebec.

Please send me more information on the Du Pont engineering materials checked: ☐ *ZYTEL;* ☐ *ALATHON;* ☐ *TEFLON;* ☐ *LUCITE. I am interested in evaluating these materials for:*

NAME_____ POSITION_____

COMPANY_____

STREET_____

CITY_____ STATE_____

TYPE OF BUSINESS_____

NEED MORE INFORMATION?

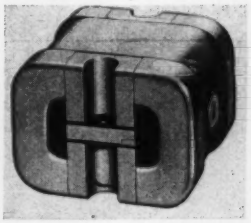
For complete details that will help you further evaluate these Du Pont engineering materials for use in your product development programs, mail the coupon at the left. Specific property and application data will be sent to you.

variable altitudes. **Rotron Mfg. Co.**, Schoonmaker Lane, Woodstock, N. Y.

—Circle ITEM 465

Torque Motor

generates 8-lb force on 3-w input



Model 24 torque motor, weighing 11½ oz, has output of 8 lb of force for 3 w of input power. Designed to drive hydraulic servovalves or similar mechanisms, it may be operated by electronic, magnetic or transistor amplifiers. Stroke is ±0.010-in. and is proportional to input differential current. Symmetrical armature is not affected by large lateral accelerations. Operating temperature range is −65 to 165 F, and the unit may be ordered for operation at higher temperatures if desired. Coils are offered to match either high or low-impedance driving sources. **Raymond Atchley Inc.**, 2340 Sawtelle Blvd., Los Angeles 64, Calif.

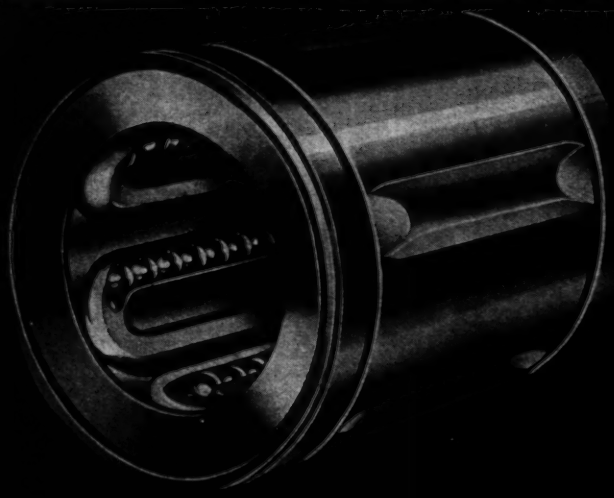
—Circle ITEM 466

High-Speed Belts

hold up under 100,000-rpm spindle speeds

Designed especially for very high speed drives, this Ultra-Speed flat transmission belt withstands spindle speeds in excess of 100,000 rpm for extended periods over small pulleys without apparent damage to the belt in either oily

BALL BUSHING



The BALL BEARING for your

LINEAR MOTIONS

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A or Low-Cost Series B BALL BUSHINGS.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Improve your product. Up-date your design and performance with BALL BUSHINGS!

Now manufactured for ¼", ½", ¾", 1", 1½", 2", 2½", and 3" shaft diameters.

LOW FRICTION • LOW MAINTENANCE
ELIMINATES BINDING AND CHATTER
SOLVES SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

Progressive Manufacturers Use Ball Bushings —A Major Improvement at a Minor Cost

THOMSON INDUSTRIES, Inc.

Dept. E, MANHASSET, NEW YORK

Write for descriptive literature and the name of our representative in your city.

Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

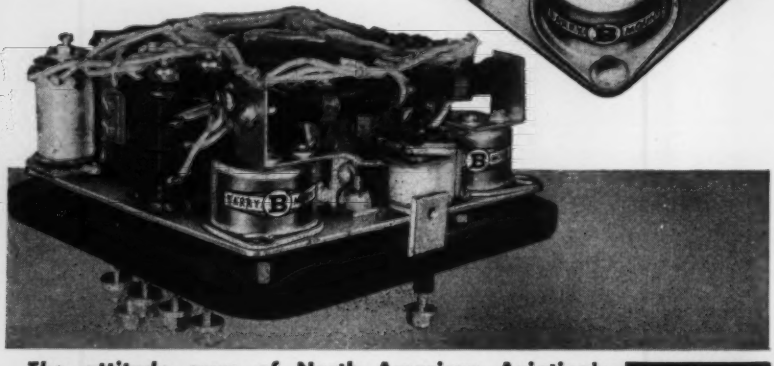
—ITEM 575—

Here's ALL-ANGL Reliability

in Minimum Space

for JETS and MISSILES

ALL-ANGL Mounts integral with base of relay interlock assembly built by Diaphlex Division of Cook Electric Company for F 86 and F 100.



The attitude gyro of North American Aviation's F-100 Super Sabre must give reliable indication through every flight attitude — or the pilot won't know which way is up.

That's why ALL-ANGL Barry Mounts are chosen to protect the delicate sensing relays in the interlock assembly for this vital instrument. Close-tolerance operation in all attitudes demands the certain isolation of vibration — assured by ALL-ANGL Barry Mounts.

F-100 Super Sabre photo courtesy of North American Aviation, Inc.

Two added advantages result:

1. Size of the unit is cut 40% by integrating ALL-ANGL mounts, upside down, in the base plate.
2. Short leads replace long cables because the Barry Mounts float the assembly within its case.

When your problem is protection through all flight attitudes, your answer is ALL-ANGL Barry Mounts. Write for Data Sheet #56-01 giving detailed information. For recommendations on specific problems, call your nearest Barry Sales Representative.

Barry's Western Division, **in Burbank, California, will offer engineering facilities, prototype service, and short-run production of "specials".**

BARRY CONTROLS INCORPORATED

BARRY B MOUNT

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

722 PLEASANT STREET, WATERTOWN 72, MASSACHUSETTS

—ITEM 576—

New Parts

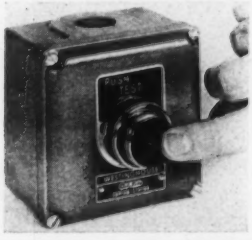
atmospheres or elevated temperatures. Belt material is a blend of synthetic and natural fibres. It is durable, will not fray, and has excellent edge wear. **Russell Mfg. Co.,** 87 E. Main St., Middletown, Conn.

—Circle ITEM 467

Indicator Light

push-to-test unit can be checked for lamp failure

When control-circuit trouble is suspected, this push-to-test indicating light shows whether an unlit indicator lamp is an indication of trouble, or merely the result of lamp failure. By pressing the lens of the lamp unit, the operator transfers the lamp from its normal circuit to a separate built-in lamp-test circuit. If lamp is functioning, it will light normally to indicate that trouble shooting is in order. If it fails to light, replacement of the faulty lamp can be quickly carried out. Open, cover, or panel mounting units are available for 110, 220, and 440-v applications. Dimensions are identical with those of standard units. **Westinghouse Electric Corp.,** Standard Control Div., Beaver, Pa.



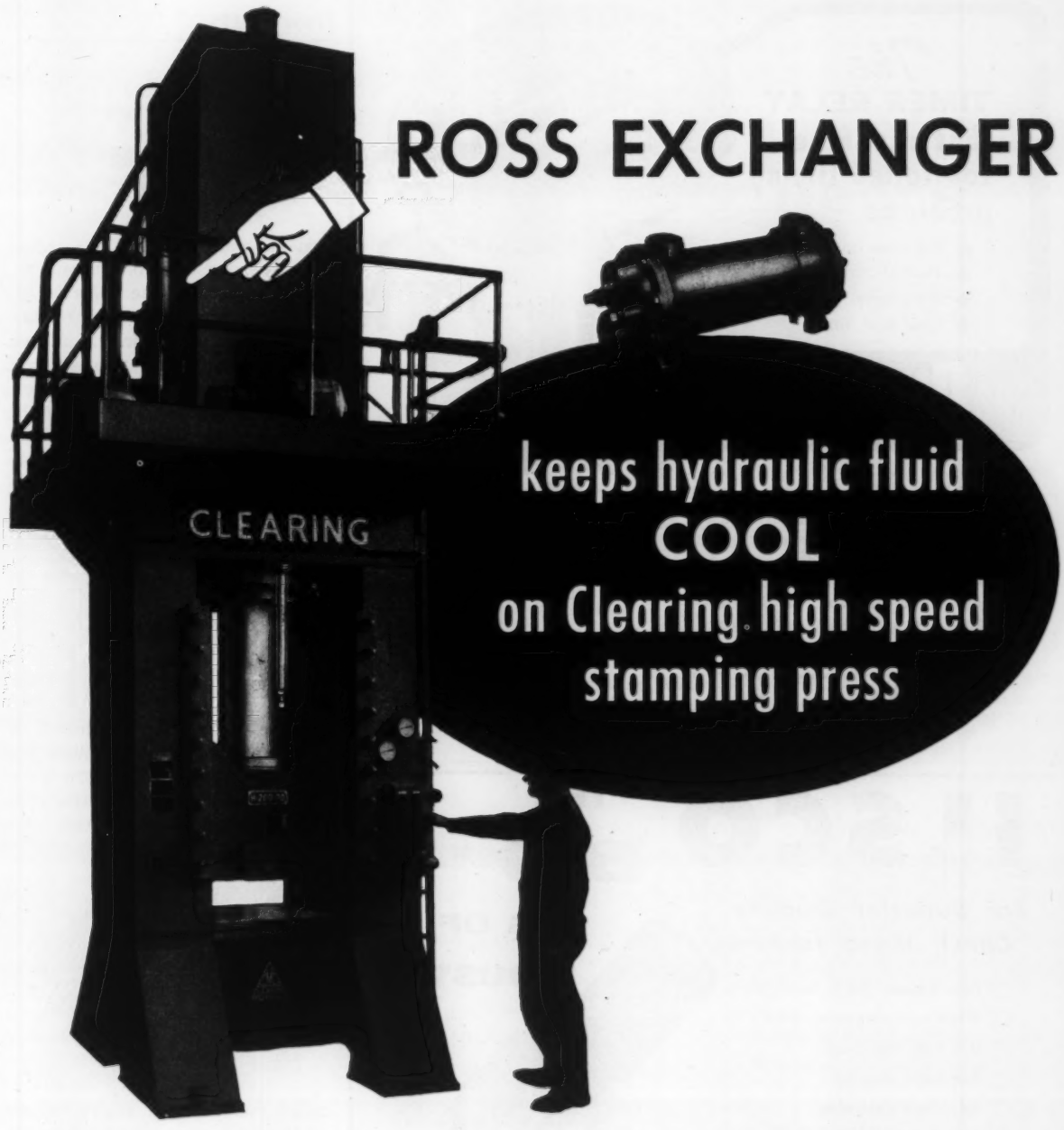
—Circle ITEM 468

Explosive Valve

opens in 0.002-sec

This lightweight Conax explosive valve is a normally-closed, dead-tight shutoff valve for control of gas or liquid under high pressures. It operates almost instantaneously when a completely enclosed explosive squib is fired, opening an equivalent orifice 9/32-in. in diam 0.002 sec after actuation. Products of combustion are completely sealed in the explosive chamber, preventing contamination of the

ROSS EXCHANGER



keeps hydraulic fluid COOL on Clearing high speed stamping press

Performing short draw operations, this 300-ton Clearing Hydraulic Stamping Press is used in high speed production of shells.

To prevent pump slippage from overheated, thinned oil, Clearing furnished a Ross Type BCF Exchanger.

"The purpose of the Ross Exchanger is to keep hydraulic fluid cool. Ross equipment has proven itself dependable and efficient," says Clearing Machine Corporation, Division of U.S. Industries, Inc.

First in ruggedness and high thermal efficiency, Ross Exchangers are regularly installed on practically every type and make of machinery requiring temperature control of lube oil, jacket water and hydraulic fluid. Pre-engineered and fully standardized, they're available in a wide range of sizes to meet your requirements.

For additional information, request Bulletin 1.1K5. Ross Heat Exchanger Division of American-Standard, Buffalo 5, N. Y. In Canada: American-Standard Products (Canada) Limited, Toronto 5, Ont.

ROSS

ROSS HEAT EXCHANGER PRODUCTS

—ITEM 577—

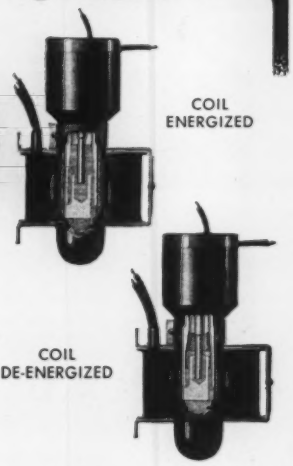
The
TIMER RELAY
that eliminates controlled timing problems

★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer

1936 · 20th ANNIVERSARY · 1956
DURAKOOL

Durakool
STEEL MERCURY TIMERS

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Any combination of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.



See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 WESTON RD., TORONTO 9, CANADA

Send for Bulletin 800

—ITEM 578—

ILSCO THE BIG LUG OF INDUSTRY

For Superior Quality
√ Check these features

- ☐ Pure copper, 100% conductivity
- ☐ Wide wire range—re-usable
- ☐ U/L-CSA Approved
- ☐ Compact—rugged
- ☐ Advanced designing
- ☐ Sound engineering
- ☐ Speedy installation
- ☐ Cool operation—takes overload
- ☐ No special tools needed
- ☐ All screws wax-treated for better clamping

ALL THESE FEATURES AT LOW COST

Your √ Test Will Prove ILSCO Superiority Over Cast Or Any Other Type Lugs

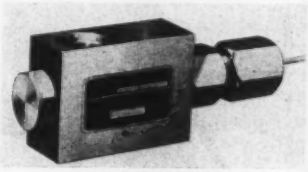
Write for Catalog #50 and Samples

ILSCO CORPORATION

5752 MARIEMONT AVE. CINCINNATI 27, OHIO

—ITEM 579—

New Parts



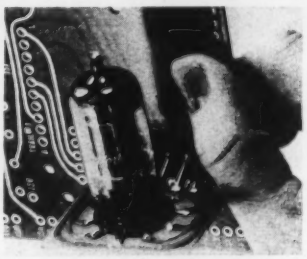
system and reducing the noise level of firing to zero. Current required to actuate the valve is ½-amp. Maximum operating pressure of standard model, which has an aluminum body and stainless steel trigger, is 5000 psi; proof pressure is 10,000 psi. Valve can be supplied with five different inlet and outlet port arrangements; port connections run from ⅛-in. IPS to 9/16-in. NF. **Conax Corp.**, Explosive Products Div., 7811 Sheridan Dr., Buffalo 21, N. Y.

—Circle ITEM 469

Angle Tube Socket

rugged unit is designed for vertical circuit boards

For use where space is limited, or where printed circuit boards are plugged vertically into larger units or terminal strips, this angle tube socket incorporates buttress ribs



which maintain the angle position of the socket to the printed circuit board. It cannot be accidentally bent out of position or torn from the board. **Cleveland Metal Specialties**, 1783 E. 21st St., Cleveland 14, O.

—Circle ITEM 470

Flexible Epoxy Resin

withstands heavy shocks without cracking

Flexible epoxy insulating resin is adaptable for production-line casting of coils and other electrical components where extreme temperature changes or forces of ex-

Promotion for Engineers

it takes more than ability for an engineer to achieve promotion

It also takes *opportunity for promotion*. There must be room for a man to move up.

If your career progress has been held back by lack of promotional opportunity, we think you will be interested in Lockheed diversification. Forty to fifty major projects are in progress continuously. Commercial and military activities span virtually the entire spectrum of aeronautical endeavor.

There is plenty of room to move up at Lockheed, simply because there are more supervisory positions to be filled with so many projects constantly in motion.

It's worth discussing. Why not write or phone collect, if you possess an engineering degree or actual engineering experience.

Address written inquiries to E. W. Des Lauriers or use the coupon below. If you phone, call STanley 7-1241, Extension 6-2134.

To Engineers Who Lack Aircraft Experience:

Aircraft experience is not necessary to join Lockheed. It's your engineering training and experience that count. Lockheed trains you for aircraft engineering—at full pay.

Advanced education program for engineers

You can expand your technical knowledge and achieve advanced degrees through a variety of Lockheed-sponsored university programs that cost you little or nothing.

Positions are open on virtually all levels in fields of:

AERODYNAMICS

FLIGHT TEST ENGINEERING

MATHEMATICAL ANALYSIS

OPERATIONS RESEARCH

STRUCTURES

THERMODYNAMICS

WEIGHT

DESIGN
in controls, electrical, hydraulics, mechanical, power plant and structures areas

ELECTRONIC SYSTEMS
in communications, counter-measures, fire control, navigation, radar and antenna design

Lockheed

AIRCRAFT CORPORATION
California Division
BURBANK, CALIFORNIA

—ITEM 580—

E. W. Des Lauriers, Dept. PE-11-8
Lockheed Aircraft Corporation, Burbank, California

Dear Sir: Please send me your brochure detailing life and work at Lockheed.

Name

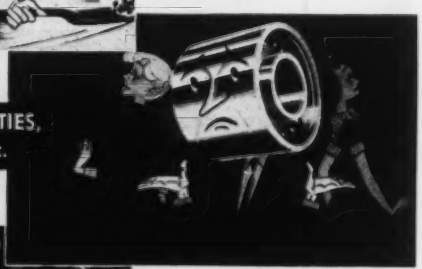
If you are an engineer, please state your field of engineering

Home street address

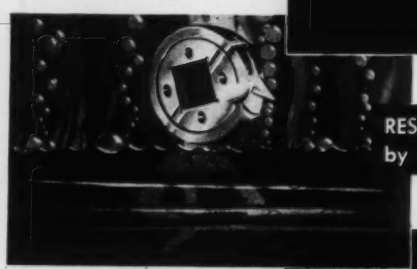
City and State Home phone

If you need BEARINGS with UNUSUAL CHARACTERISTICS such as . . .

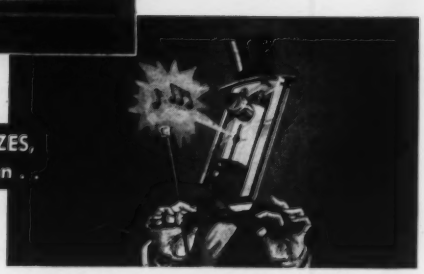
HEAT RESISTANCE — to 500° – 1000° – 1500° F



NON-MAGNETIC PROPERTIES, electrical conductance, etc.



RESISTANCE TO CORROSION by Acids – Caustics – Salts



SPECIAL SHAPES AND SIZES, low torque, ultra precision . .

. . . very likely, we can supply them — designed and built to your own specific requirements — in experimental or production quantities. We've been doing that for years, for well-known companies — often working closely with their own engineers. So, if *you* need special anti-friction bearings for *any* purpose, let's talk it over.

Free 32-page Bearings Bulletin tells about the factors involved in special bearing applications, and describes our work in this field. *Write for it!*

INDUSTRIAL TECTONICS, Inc.

3680 Jackson Rd., Ann Arbor, Michigan
5002 E. Washington Blvd., Los Angeles 22

ITI

PRECISION BALLS OF ANY SIZE OR MATERIAL
ANTI-FRICTION BEARINGS FOR SPECIAL REQUIREMENTS
TOOLING BALLS — MASTER BALLS — SPHERICAL FINISHING

—ITEM 581—
For More Information Circle Item Number on Yellow Card—page 19

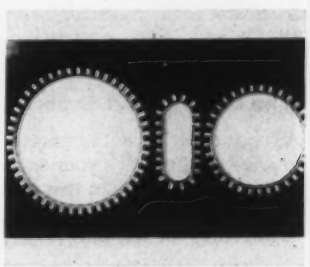
panding and contracting metals can cause cracking of nonflexible materials. Called Scotchcast, the resin retains its flexibility because of molecular structure rather than by addition of a plasticizing material. In addition to the flexible resin, CRP 235, filled and dipping resins can be supplied. Viscosity is from 1500 to 2000 centipoise at 25 C. When heated to 140 F before pouring, viscosity of the resin is 60 centipoise. Shock and heat resistance, adhesion to metals, and electrical properties are those characteristic of conventional epoxy resins. **Minnesota Mining and Manufacturing Co.,** 900 Fauquier St., St. Paul 6, Minn.

—Circle ITEM 471

Strip Grommet

can be contoured to any shape opening

Supplied in 10-in. strips, or cut to customer specifications in any length, these nylon strip grommets can be snapped into openings of any shape, such as circular, elongated or oval. Eliminating the need for a stock of special size



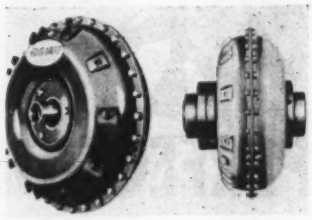
grommets, the strips are applicable to metal thicknesses from 0.015 to 0.128-in. **Nylon Molding Corp.,** 141 South Ave., Garwood, N. J.

—Circle ITEM 472

Fluid Drive

provides smooth starting, shock isolation

Traction-type Gyrol fluid drive is designed for simple installation on electric motors or internal combustion engines. Basic unit (left), designated 126 type T, is for use with internal combustion engines, such as those driving material handling vehicles or construction



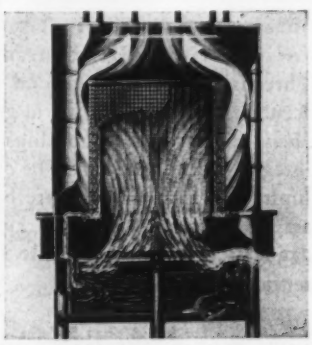
equipment. Power rating for this model is 25 to 85 hp, depending upon drive speed. When modified by installation of flexible couplings the unit is suited to constant-speed electric-motor applications in production or processing equipment, machine tools, conveyors and other material handling installations. As a motor-drive unit, size 126 fluid drive (right) is rated 7½ to 15 hp for 1200-rpm drive speed, and 25 to 50 hp for 1800 rpm. Construction is die-formed, resistance-welded, and runner and impeller assemblies ride on two ball bearings which take internal thrust. Dimensions of basic unit are 7½ in. over the shaft, and 14 15/16 in. OD. Overall length for the electric motor arrangement is 10 13/16 in. **American Blower Corp.**, Detroit 32, Mich.

—Circle ITEM 473

Air Filter

has oil scrubbing action, minimum pressure drop

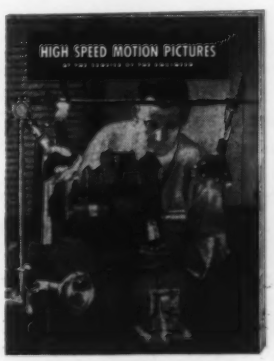
Low pressure drop operation without moving parts or outside energy supply is attained by this LPD oil bath air filter. Tests with the



filter—using standard air cleaner fine dust—showed a high level of efficiency, with 97.5 per cent of the dirt arrested. Smallest of the four models, recommended for variable-speed engines and com-

Everyone working on design and performance problems of fast mechanical motion should have a copy of "High Speed Motion Pictures at the Service of the Engineer," a new booklet obtainable without charge from . . .

EASTMAN KODAK COMPANY
Rochester 4, N. Y.



It tells about the new fast films for high speed movies and how various industries are using the Kodak High Speed Camera.

Kodak

—ITEM 582—

Square World?

Not a Chance!

A *sphere* is the Universal answer! And, perhaps, a sphere can answer your designing problems—a ball that rolls around and around, and serves the world in thousands of ways!

Universal makes these balls in almost any material. Makes them to tolerances of 5 millionths of an inch—to suit *your* needs!

Set your ideas rolling along on a ball. And, for best results, specify Universal!

UNIVERSAL QUALITY CONTROL—
FOR ALL ROUND PERFECTION!

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

—ITEM 583—

New Parts

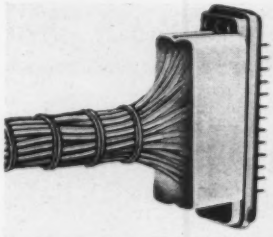
pressors, has capacity range from 800 cfm to 3500 cfm with pressure drop of 0.6-in. of water at minimum flow and 4.8 in. at maximum. Largest models, for constant-speed engines and compressors, range in capacity from 16,500 cfm to 24,000 cfm with pressure drop from 1.9 to 3.5 in. Air-flow regulator tube is factory preset so that, within the filter's rated capacity range, air velocity will be sufficient to insure full oil washing. To facilitate servicing, filter has a quick-opening drain valve, and weather hood and oil sump are arranged for easy disassembly. **Air Maze Corp.**, 25000 Miles Rd., Cleveland 28, O.

—Circle ITEM 474

Potting Shells

protect cups and wires of miniature connectors

Intended for application after connector contacts are wired, molded plastic potting shell and sealing compound provide complete protection for solder cups and wires. Connector is sealed against moisture, and cable strain under extreme vibration or repeated connect and disconnect is minimized. Shell can be supplied for various connector types and sizes. **DeJur-Amsco Corp.**, Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.



—Circle ITEM 475

Motorized Reducer

has single-base mounting for quick set-up and alignment

Line of motorized reducers, called Line-O-Motor, combines the advantages of integral-motor reducer units with the versatility of separately mounted motors. Unit base supports both reducer and motor, facilitating set-up and shaft

STOP!

PERFECTION

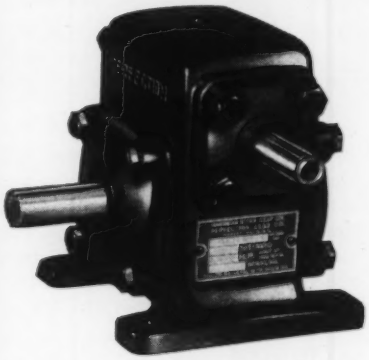
WORM GEAR

SPEED REDUCERS

available in

5

COMPLETE SERIES



Don't go hunting around for Speed Reducers. Your nearest distributor has a complete series of Perfection Speed Reducers with ratios ranging from 5 to 1 to 60 to 1. Furnished with worm on top or bottom as desired.

Shafts are mounted in Timken anti-friction roller bearings. Threads are precision ground and accurately mated with worm gear. Heavy rigid cast iron housings . . . integral worm and shaft. The close limits to which all parts are held, assure maximum load carrying capacity, and long trouble free service.

Write for free 8 page Bulletin No. R-20 listing the complete Perfection Series.

AMERICAN STOCK GEAR DIVISION
Perfection Gear Company • Harvey, Ill., U.S.A.

—ITEM 584—

Handles coated with vinyl-foam for

Smooth grip...

cushioned grasp

Coating of foamed vinyl plastisols makes these scissors more comfortable to use, with a very small increase in cost. Plastisols based on BAKELITE Brand Vinyl Resins formulated by **The Stanley Chemical Company,** East Berlin, Conn., for **John Ahlbin & Sons, Inc.,** Bridgeport, Conn.

. . . and this new comfort makes them easier to sell! Colors are used to add new eye-appeal for further sales-appeal. An additional advantage to the manufacturer is that the application of foamed plastisols based on BAKELITE Brand Vinyl Resins is fast and economical . . . can keep competitively priced products in line with the competition; hand polishing and plating of rough castings can often be eliminated.

Perhaps your product needs a new "handle." Foamed plastisols based on BAKELITE Vinyl Resins may give you a new, lower cost solution to your problem. Color selection is wide allowing for easy visual identification . . . and colors stay true. Plastisols resist moisture, acids and the smooth surface makes the handles virtually dirt proof. Why not investigate foamed plastisols based on BAKELITE Brand Resins today? Write Dept. SS-103.

BAKELITE BRAND Vinyl Resins

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

—ITEM 585—

"FAIRFIELD for FINE GEARS"

WHAT **FAIRFIELD**
Experience MEANS TO YOU

Experience is the "plus value" that goes into every Fairfield gear *at no extra cost.* It is your assurance of dependable gear performance combined with the utmost in production economy. By specializing exclusively in "Fine Gears Made to Order" for more than thirty-five years, Fairfield has become one of America's largest independent producers of these parts. This is why many makers of Construction Machinery . . . Agricultural Implements . . . Machine Tools . . . Material Handling Equipment . . . Trucks, Tractors, and Buses now regularly depend on Fairfield to meet their requirements.

Fairfield's facilities are unexcelled. Here, in a new and ultra-modern plant you will find a complete metallurgical department, batteries of the most modern machines, testing laboratories, latest heat treating equipment—all operated by skilled craftsmen working under expert engineering supervision. *For the Best in Gears, Specify Fairfield!*

FAIRFIELD
MANUFACTURING CO.

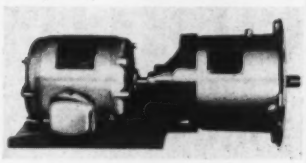
2307
S. Concord Rd.

Lafayette,
Indiana

—ITEM 586—

New Parts

alignment. Motor mounting bracket slots are standardized to suit all NEMA motors. Available in horizontal models for foot mounting or



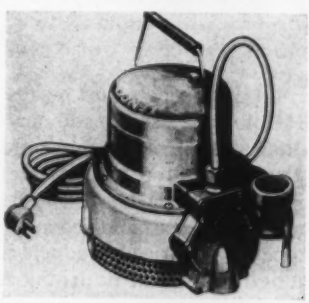
in vertical and vertical extended housing models for flange mounting, units are rated from 1 to 75 hp. Double, triple or quadruple reductions provide a selection of ratios from 5.06:1 to 238:1. **Foote Bros. Gear & Machine Corp.,** 4545 S. Western Blvd., Chicago 9, Ill.

—Circle ITEM 476

Submersible Pump

guaranteed to start without priming

Model 140 submersible multipurpose pump for automatic intermittent or continuous submerged duty, such as in machine tool coolant systems, offers guaranteed starting without priming difficulties. Built-in check valve prevents fluid from running back into the tank after the pump stops. Air locks are eliminated by a valve



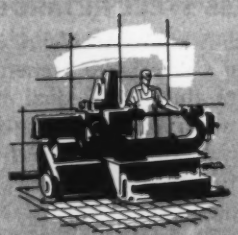
that allows rising water to expel air, but instantly closes when the pump starts. Measuring 7½ in. high by 10 in. wide and weighing 25 lb, it is rated at 3000 gph. Flood-proof operation and long-life lubrication of motor and bearings are provided by ceramic and carbon seals, which keep oil in and water out. **American Crucible Products Co.,** Kenco Pump Div., 1305 Oberlin Ave., Lorain, O.

—Circle ITEM 477

For More Information Circle Item Number on Yellow Card—page 19

A complete line of Roller Bearings . . .

For every field of transportation and industry

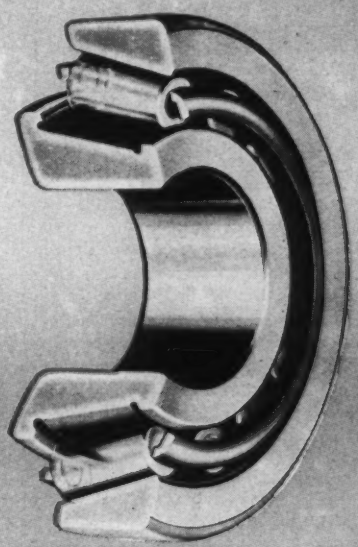


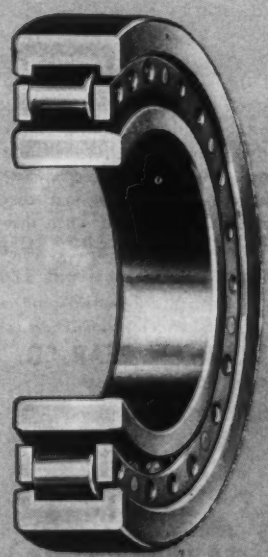
Job-tailored in a wide range of sizes to fit your specific needs

Aircraft? Automobiles? Earth-moving or farm equipment? *Whatever* you make, if your product uses straight or tapered roller bearings, Bower can meet your specifications *exactly*. For dependable Bower bearings are virtually custom-built to the job . . . engineered and sized to match any requirement.

Important, too, are exclusive Bower design features that assure long life, top performance, *less maintenance*. And when you specify Bower bearings you can always be certain of the highest quality materials and workmanship. These reasons, of course, are why Bower straight, tapered and journal roller bearings are used by leading manufacturers everywhere—for any application.

Let a Bower engineer give you full details of the complete Bower line. Call him in while your product is still in the design stage.





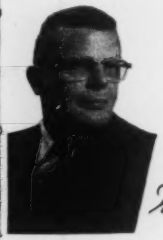
BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION • *FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICH.*

—ITEM 587—

For More Information Circle Item Number on Yellow Card—page 19

Finding the ROTTEN APPLE *in the* BARREL



William O Dunn

CHIEF INSPECTOR, THE CINCINNATI GEAR CO.

Several years ago we ran an ad entitled "Ears for Gears" that produced a lot of comment. The unusual title was explained in the copy, in which we told how we can individually *sound check* gears for minimum noise level. This checking is done on ultra-modern testing equipment, under specified load and R.P.M., measuring the decibel tolerances of the individual gears. Not only does this help us produce silent-running gears, but it is also one example of the extensive checking and testing to which we subject our gears, to be *sure* of maintaining our reputation for delivering only *good* gears.

This checking and testing, which is the responsibility of my department, is one of the most important functions in our plant. It's always *possible* for a "rotten apple" to slip into the barrel, but it's *essential* that it be found and removed before shipping. That's why my department can't afford to make any mistakes, or compromise in any way. Top management realizes this; they provide us with the best available equipment, and I report directly to our President (eliminating any possibility of "shop influences" in our testing standards). As a result, our customers have the assurance that when they send us an order they'll receive only the best custom gears obtainable.

THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
"Gears—Good Gears Only"

CINTI

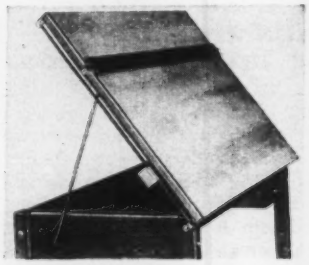
—ITEM 588—

ENGINEERING DEPARTMENT EQUIPMENT

Counterbalance

supports straightedges on near-vertical boards

For use on steeply inclined or vertical drawing boards, this straightedge counterbalance is adjustable to balance the weight of any straightedge. It can be used with any of the several styles of Mayline straightedges, or with any other straightedge that uses the under-board type attachment. Rod of the counterbalance comes in standard 44-in. lengths; for narrower tables, the rod can be cut to the length required. **Mayline Co.,** 619 N. Commerce St., Sheboygan, Wis.

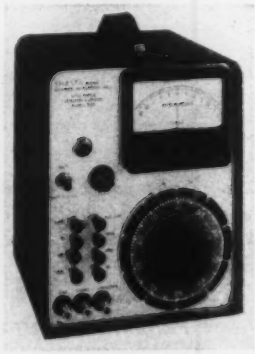


—Circle ITEM 478

Resistance Bridge

wide-range instrument gives rapid resistance check

Resistance values in seven ranges from 100-ohm to 100-megohm are



COOPER ALLOY CORPORATION BRIEFS

• Edited by GEORGE BLACK

CORED SIGMA BLADE

1500 lb. stainless steel sigma blade not only has to be corrosion resistant and dimensionally accurate, but a 1½" cored hole, centrally located with respect to the various cross sections is required throughout its length

The full story is told in Cooper Alloy AKH #4.

KEL-F LINERS FOR VANTON PUMPS

The addition of Kel-F to the long list of rubbers and plastics now available for liners makes the Vanton pump suitable for handling such media as fuming nitric and other strong oxidizing acids, mineral acids, alkalies, aliphatic solvents and hydraulic fluids.

Details on request.

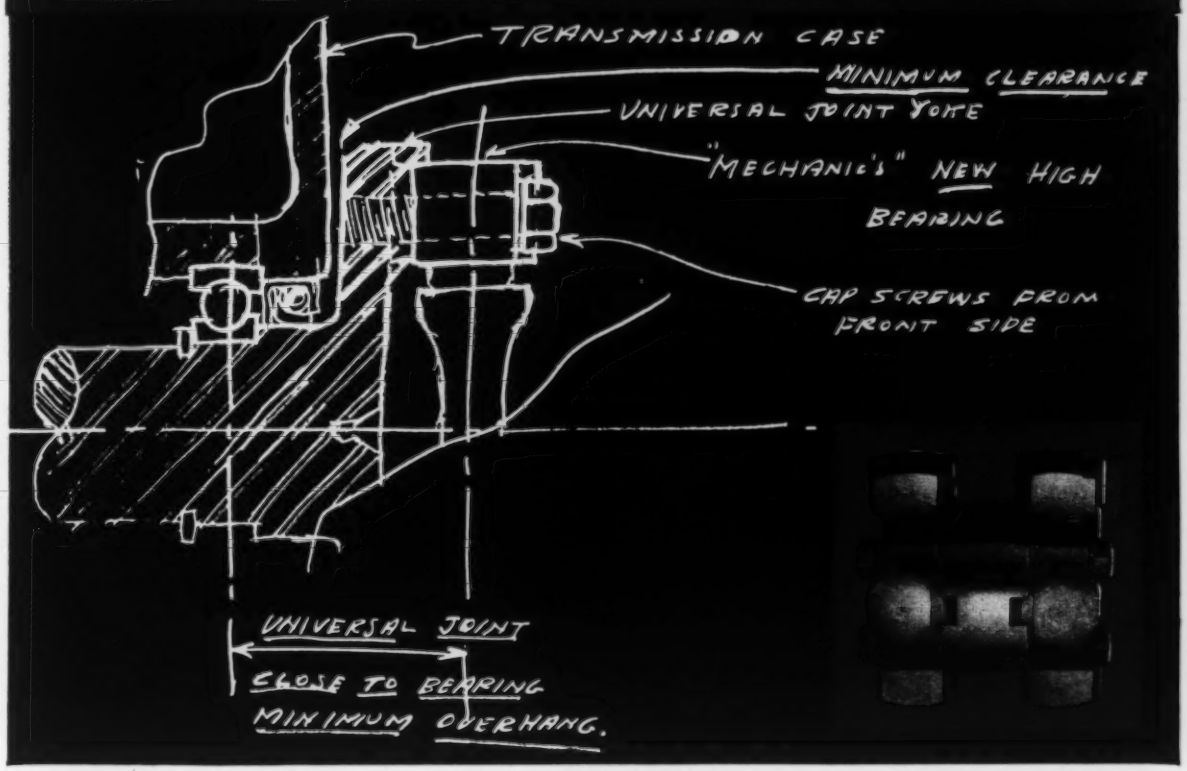
STAINLESS STEEL RETARDERS

Cooper Alloy stainless steel retarders in the Cyclotherm Generator help to produce additional heat transfer with maintenance-free reliability. Known as Cyclotherm Cyclonic Combustion the new principle delivers a guaranteed 80% heat transfer in two passes and drops maintenance costs as much as 50%.

COOPER ALLOY
CORPORATION • HILLSIDE, N J

—ITEM 589—

SOLVE YOUR CLEARANCE PROBLEM THIS WAY



If you are faced with the problem of locating a universal joint in a space where limited clearance does not permit the use of a flanged joint, MECHANICS close-coupled Roller Bearing UNIVERSAL JOINT is your solution. This joint is specially designed for operation within cramped quarters that engineers formerly considered too short to accommodate a universal joint. Let our engineers show you how MECHANICS close-coupled UNIVERSAL JOINTS will conserve space, compensate for offset shafts and provide ample angularity in your new, compact models.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International
36 So. Wabash, Chicago 3, Illinois

MECHANICS
Roller Bearing B-W
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

—ITEM 590—

Here's another new device for the designer

THE FLEX'ATOR® COMPRESSION SPRING

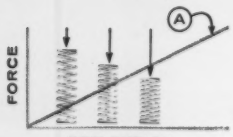


Fig. 1. The gradient (or spring rate) of a conventional compression spring is illustrated by line A above. Note that force changes in direct proportion to displacement.

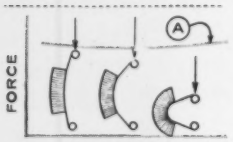


Fig. 2. The unusual force pattern of a FLEX'ATOR Compression Spring is illustrated by line A above. Note that there is a very slight change in force over the entire stroke.

The new Hunter FLEX'ATOR Spring exerts virtually constant force throughout its compression stroke—is another new "one-force" mechanical loading device for product designers.

The patented FLEX'ATOR is a close-wound spring body (with pre-calculated initial tension) which has equal arms extended at an angle to the body. Loops or other arrangements are provided on the arm ends for fastening.

This new spring element exerts force as it is *flexed* rather than stretched or squeezed. In addition to close-to-constant force in compression, the FLEX'ATOR can be designed to provide increasing and decreasing force deflection characteristics as well—making this new component ideal for a host of critical applications.

To learn more about this new design element, request Bulletin 313A which describes it and includes preliminary design data. Also, if you write *direct to us*, we will gladly send you a *sample* FLEX'ATOR for your own first-hand examination.

THE HUNTER flex'ator compression spring

HUNTER SPRING COMPANY

3 Spring Avenue, Lansdale, Pennsylvania

SPRINGS • STAMPINGS • TEST APPARATUS

—ITEM 591—

Engineering Equipment

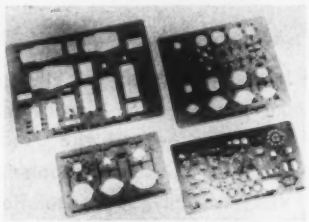
checked rapidly and easily by model 605 wide-range resistance bridge. Offering push-button range selection, the instrument has an accuracy of ± 0.15 per cent + 0.05 per cent full scale. Lowest measurable resistance is 5 ohms. In operation, the unknown resistance is connected to the instrument terminals, the range switch set, a key depressed, and the precision potentiometer adjusted for null indication on the 4-in. zero-center galvanometer. Value of the unknown is given directly on the potentiometer dial, with a multiplication factor applied as indicated. **Beckman Instruments Inc.**, Shasta Div., P. O. Box 296, Station A, Richmond, Calif.

—Circle ITEM 479

Template Set

for electronic components

Matched set of dimensionally stable Vinylite templates saves substantial drafting time in layout of tubes, sockets, bases, switches and similar electronic



components. Templates are supplied individually, or as a four-piece kit. **A. Lawrence Karp**, 16 Putnam Park, Greenwich, Conn.

—Circle ITEM 480

Reactance Slide Rule

speeds calculations of ac circuit parameters

Inexpensive reactance slide rule offers a time saving means for calculating resonant frequency, capacitive and inductive reactance, coil Q and dissipation factor. Scales cover a frequency range from 5 cps to 10,000 megacycles. **Shure Bros. Inc.**, 222 Hartrey Ave., Evanston, Ill.

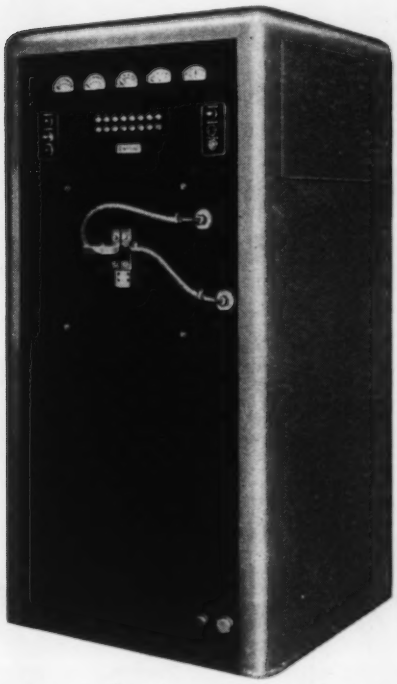
—Circle ITEM 481

To help improve induction heating applications, Lindberg engineers have spent two years developing equipment for M-G set frequencies of 1 kc., 3 kc. and 10 kc. This equipment is now available to you.

This development has also produced many advanced design features that are incorporated in control and heating stations used in connection with motor generator equipment.

Generators are available in power outputs from 30 kw. to 1250 kw.

Lindberg engineers are now equipped to solve your metal heating problems using optimum frequencies for specific applications from 60 cycles upwards. For information consult your nearest Lindberg field office or write for Bulletin No. 1460.



The High Frequency Division of Lindberg Engineering Company announces a complete line of MOTOR GENERATOR EQUIPMENT for all Induction Heating Applications

HIGH FREQUENCY DIVISION
Lindberg Engineering Company
2473 W. Hubbard St., Chicago 12, Illinois

—ITEM 592—

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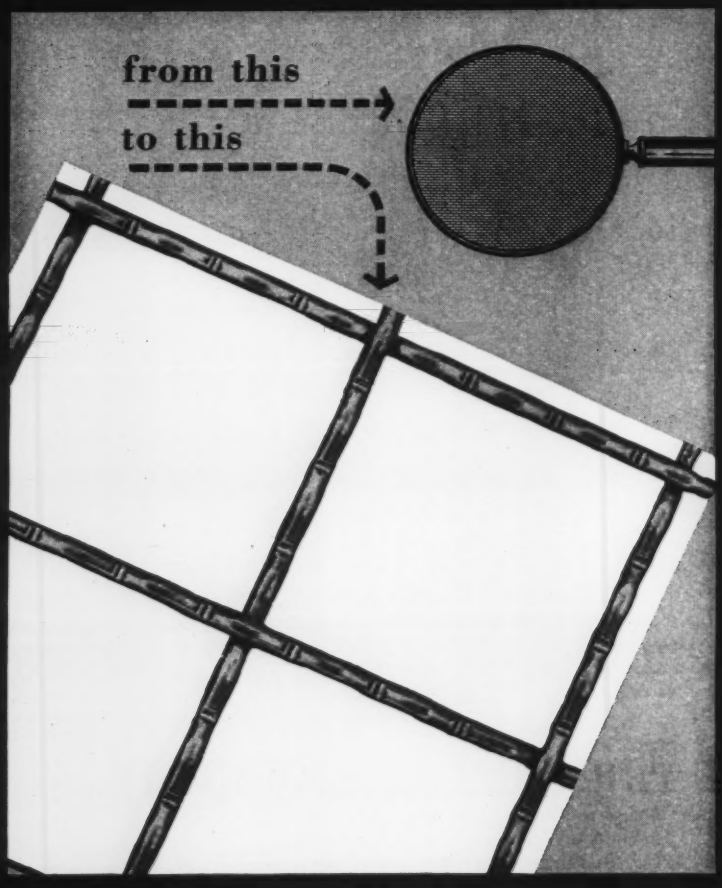

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Professional Viewpoint

More on What Price Experience

To the Editor:

Your editorial "What Price Experience?" (April 5 issue) says a great deal and, at the same time, it leaves much more unsaid.

It is, of course, not an exclusive characteristic of engineers to grow negative after a number of years on the job. It is a human characteristic.

Why do managers wait 10 or 20 years until they finally realize that a man has grown to be negative?

In my way of thinking, a manager who sees the first sign of a man becoming negative should take steps to prevent further growth. It is like cancer—prevention or early discovery are the only cures.

The whole story of the shortage of engineers has not been told, and if it were, there would be many red faces.

The idea of hiring new graduates and training them is not new, but training of engineers already in industry is not very well organized.

Recent graduates are given either a fairly short intensive course or turned over to older engineers. In the long run it means that they shift for themselves, and no one seems to notice when they are becoming negative.

There are very many retired engineers, stagnating in their retirement, who became negative because they were not given the proper supervision. Many of these engineers, not all of course, have learned their lesson and could be still useful in industry.

Despite the fact that there are a few intelligent psychometric tests, management does not want to bother to use them in selecting those older engineers who could be useful in industry. It is much easier to hire new graduates.

—JOSEPH C. RAH, *President*
Aircraft & Electronic Specialties, Inc.

Adjustable Speed

Is Your Drive Problem in this List?

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- ☐ Wind Tunnels
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- ☐ Conveyors
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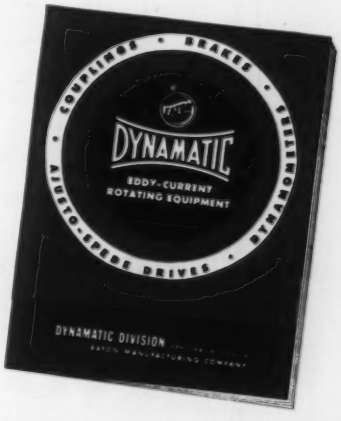
Eddy-Current Equipment Can Be the Solution

Using standard AC lines as a power source, Dynamatic torque transmitting equipment satisfies most stepless adjustable speed requirements. Dynamatic Ajusto-Spede® and Dynaspede® Drives, Couplings, Brakes, and Dynamometers with electronic or magnetic amplifier control provide the advantages of rapid response, wide speed range, quiet operation, low power losses, low maintenance cost, and remote control.



Send for your free copy of the Dynamatic Bulletin GB-2, which illustrates and describes eddy-current adjustable speed rotating equipment.

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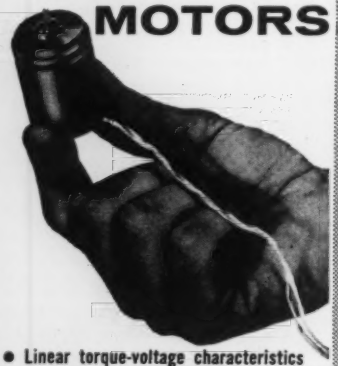
—ITEM 594—

Now on the shelf!

PRECISION SERVO MOTORS



- Linear torque-voltage characteristics
- Linear torque-speed characteristics
- Withstand continuous stalling
- High torque efficiency

Guaranteed shipment within 10 days for these units:

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CIRCLE THE MOTORS FOR WHICH YOU ARE INTERESTED IN HAVING PRICES AND DATA

WATTS	CYCLES	VOLTAGE SUPPLY	VOLTAGE CONTROL
½	400	115	180
1½	60	115	180
2½	60	115	115
5	60	115	115
5	400	115	115
5	60	115	250/250
5*	60	115	250/250
5	400	115	250/250
5*	400	115	250/250
10	60	115	115
10	400	115	115
10	60	115	250/250
10	400	115	250/250
10**	400	115	57.5/57.5

*Have double shaft extension (all others are single).
**Designed for mag-amp systems.

Mail this coupon to:

FORD INSTRUMENT COMPANY
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31-10 Thomson Ave., Long Island City 1, N. Y.
Attention: Component Sales MD

OR, call or wire R. Banka for prices (STillwell 4-9000, Ext. 513).

☐ Please send me prices on the servo motors I have circled above.

☐ Please send me fully illustrated data bulletin giving specifications and performance information.

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—ITEM 595—

THE ENGINEER'S Library

Recent Books

Resistance of Materials, 4th Edition. *By Fred B. Seely, emeritus professor of theoretical and applied mechanics, and James O. Smith, professor of theoretical and applied mechanics, both of the University of Illinois; 459 pages, 5½ by 8½ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$6.50 postpaid.*

The present edition of this text, like the previous revisions, is intended for use in a first course for engineering students and as a reference for engineers in practice. The results of recent research and experience have been included, the scope of topics has been enlarged and new problems have been added. Elementary topics include torsion of cylindrical bars, bending loads, deflection of beams, combined loads, buckling loads, repeated and dynamic loads. Additional topics include composite beams, unsymmetrical bending, elastic vibration and properties of an area.

♦

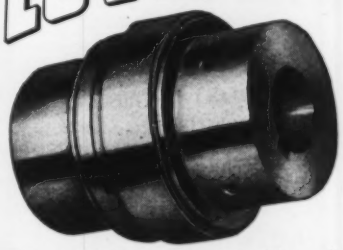
Machine Design. *By Joseph Edward Shigley, professor of machine design, Clemson College; 418 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.75 postpaid.*

Written mainly for students of engineering, this text has several objectives: to stimulate creative ability, to direct effort toward synthesizing rather than analyzing, to teach design as a formulation of decisions, to teach all the factors that influence design, and to note deficiencies in current methods of analysis. A major subdivision of the text, titled fundamentals of machine design, covers stresses and deflections in machine

15 YEARS SERVICE WITH ONE SET OF CUSHIONS

... actual report on

LOVEJOY



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Up to fifteen years maintenance-free service is not unusual with Lovejoy lubrication-free flexible couplings.

Performance like this is practical proof of these soundly engineered features:

SIMPLE, RUGGED CONSTRUCTION
Fewer parts. No intricate mechanisms. Nothing to lubricate.

LOAD TRANSMITTED BY CUSHION COMPRESSION
No wear on the metal jaws.

DOUBLE-LIFE CUSHIONS
One half of the cushions act as idlers—except on reversible loads. A quick interchange provides a new set of cushions. This can be done without dismantling the coupling.

Illustration at right shows a Lovejoy Type CF flange-mounted coupling. Rated at 160 hp., 800 rpm., this space saver connects drive shaft between diesel power unit and generator.

You can get Lovejoy performance for your application.

Let us know your requirements or request complete-line catalog.

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Mfrs. of Flexible Couplings, Variable Speed Pulleys and Transmissions, Motor Bases and Universal Joints.

—ITEM 596—

parts, properties of materials and principles of design. The second group of topics, titled selection and design of machine elements, includes screws, fasteners and joints; springs, bearings and gears; clutches, brakes and couplings; flexible and miscellaneous elements.

•

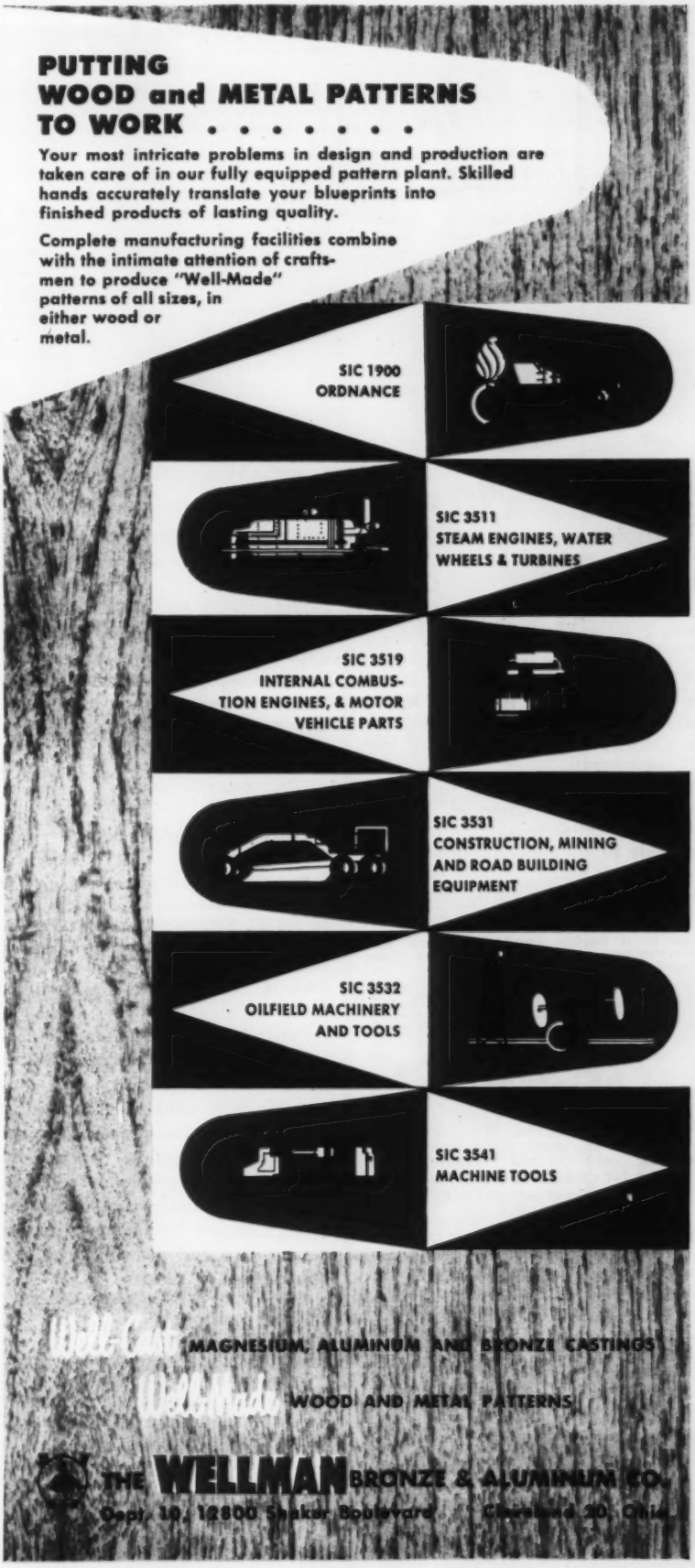
Introduction to Plasticity. *By Aris Phillips, associate professor of civil engineering, Yale University;* 229 *pages,* 6 *by* 9 *in., clothbound; published by The Ronald Press Co.,* 15 *East* 26*th St., New York* 10, *N. Y.; available from* MACHINE DESIGN, $7.00 *postpaid.*

This is an introductory text on the subject of metal plasticity written from the point of view of the stress analyst. It is considered suitable for undergraduate students, graduate students in engineering and practicing engineers. The first six chapters, which deal with one-dimensional problems, cover stress-strain diagrams and formulas, calculation of the collapse load, the moment-curvature diagram, bending with axial force, deflections, and curved bars. The last three chapters consider problems of combined stress. They cover stress-strain relations, collapse under combined stresses, and strain hardening under combined stresses.

New Standards

Hexagon Head Cap Screws, Slotted Head Cap Screws, Square Head Set Screws, and Slotted Headless Set Screws, ASA B18.6.2-1956. 21 *pages,* 8½ *by* 11 *in., paperbound; published by and available from American Society of Mechanical Engineers,* 29 *West* 39*th St., New York* 18, *N. Y.,* $1.50 *per copy.*

This standard combines in a single document the standards for the principal types of cap and set screws, except for socket-head products. The new standard supersedes parts of the standards B18.2-1952 and B18.6-1947. Kinds of information provided for the types of fasteners in the title are: defects, nomenclature, thread series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—ITEM 597—
For More Information Circle Item Number on Yellow Card—page 19

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Gear-Grip

Flexible Coupling

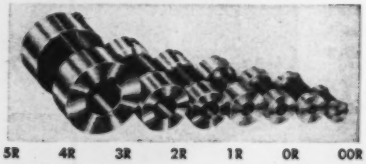
The most revolutionary design advancement for integral H.P. in a century!

Positive power transmission of rated load. Gear teeth on end castings match special rubber tube section.

- **Load ranges—2½ H.P. to 25 H.P.**
- **Shaft sizes—¾" to 1⅞".**
- **Specified lengths to design requirements.**
- **Prevents end thrust.**
- **"By Eye" shaft alignment.**
- **No lubrication required.**
- **Shaft Safety features.**

Dyna-Line . . .

The finest flexible coupling in single unit construction—specifically designed for fractional H.P.



5R 4R 3R 2R 1R 0R 00R

- **True Flexibility and Torsional Resilience for quiet, load-plus power transmission without extreme deflection or twist.**
- **Lengths varied to design specifications in each series.**
- **Load ranges—1/15 to 1½ H.P.**
- **Shaft sizes — 3/16" to ¾".**
- **Lowest O.D. for highest torque capacity.**

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Guardian PRODUCTS CORP.
COUPLING DIVISION

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—ITEM 598—

The Engineer's Library

and tolerance, slot details, heat treatment, and dimensions.

•

Investment Casting Specifications. *8½ by 11 in., paperbound; published by and available from The Investment Casting Institute, 27 East Monroe St., Chicago 3, Ill.; 70c per set of 7, or 10c per copy; numbers and titles as follows:*

MG-1 **Magnesium Base Alloys**—2 pages
NI-1 **Corrosion and Heat Resistant Nickel Base Alloys**—3 pages
AL-1 **Heat Treatable Aluminum Alloys**—3 pages
CU-1 **Silicon Brass**—2 pages
CO-1 **Corrosion and Heat Resistant Cobalt Base Alloys**—3 pages
FE-1 **Carbon Steels**—3 pages
FE-2 **Low Alloy Steels**—3 pages

These specifications are intended for the use of design engineers and others who specify investment-cast parts. These seven are the first standards issued by the Institute. Typical subdivisions of a specification are: scope, chemical composition, heat treatment, physical properties, quality, reports and identification.

Association Publications

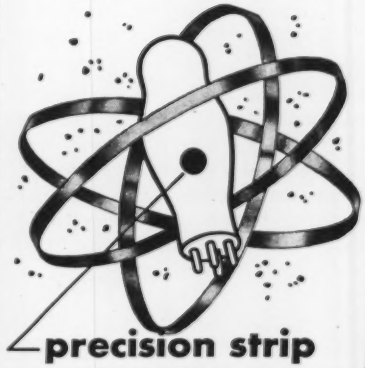
Proceedings of National Industrial Research Conference. *72 pages, 8½ by 11 in., clothbound; available from Joseph J. Kowal, Armour Research Foundation, 10 West 35th St., Chicago 16, Ill.; $6.00 per copy.*

Sponsored by the Armour Research Foundation of the Illinois Institute of Technology, the conference was held in Chicago in April, 1956. The proceedings are the compilation of 13 papers covering the accomplishments of research in particular companies, the economics and management of research, and the measurement and application of results.

•

Proceedings of the National Electronics Conference, Vol. XI. *1040 pages, 6 by 9 in., clothbound; published by and available from the National Electronics Conference, 84 East Randolph St., Chicago 1, Illinois; $5.00 per copy.*

This book is the compilation of



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From 0.0005 in. to 0.040 in. thick and 0.090 to 6 in. wide, these alloys are available as special-tolerance strip:

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Some immediately available. Others rolled to order in 2 to 21 days. Can be supplied in coils or straight lengths with slit or filed edges—also cadmium plated.

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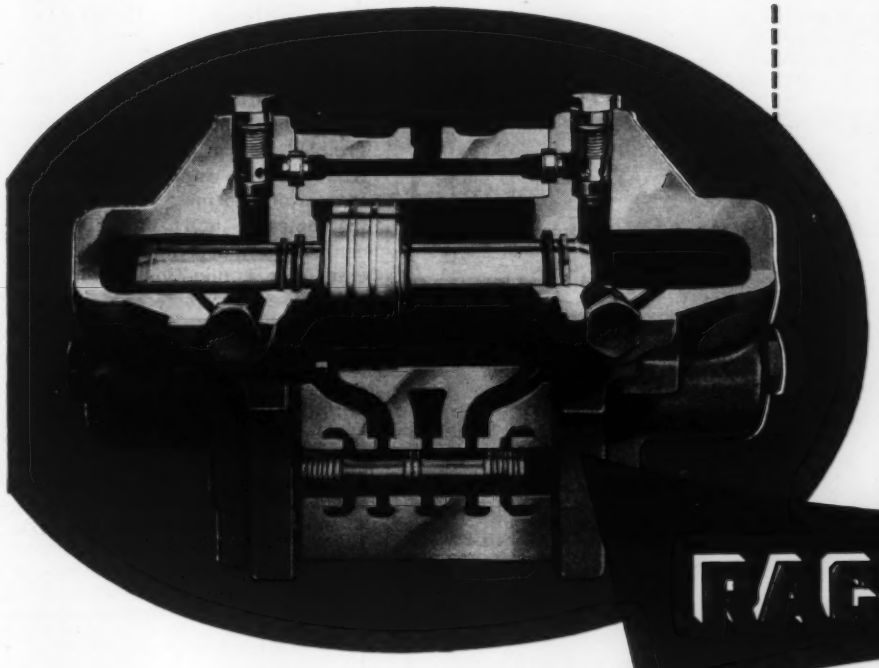
Chicago *PRECISION STEEL WAREHOUSE INC.*
Los Angeles *KRUSEN WIRE & STEEL CO.*

—ITEM 599—



RACINE®

HYDRAULIC PRESSURE BOOSTERS

HIGH PRESSURE VALUES— AT LOW PRESSURE COSTS

This patented RACINE PRESSURE BOOSTER builds pressures as high as 5000 psi. With it you can economically multiply the pressure from your low pressure pump as much as seven to one

It allows you to use low pressure at low cost for many operating and closing actions. High pressures to 5000 psi, automatically cut in for final forming and holding operations, or curing cycles on your machine.

Simple design, pressure lubricated, rugged parts and the use of extremely high tensile materials make RACINE Pressure Boosters practically indestructible They last for *years and years* with little maintenance or repair.

If you need pressures to 5000 psi, write us now. Learn how you can have "High Pressure Values at Low Pressure Costs."

OTHER RACINE HYDRAULIC PRODUCTS

MODEL Q
Variable Volume
Vane Type
Hydraulic Pump

4-WAY VALVE
Twin Solenoid
Pilot Operated

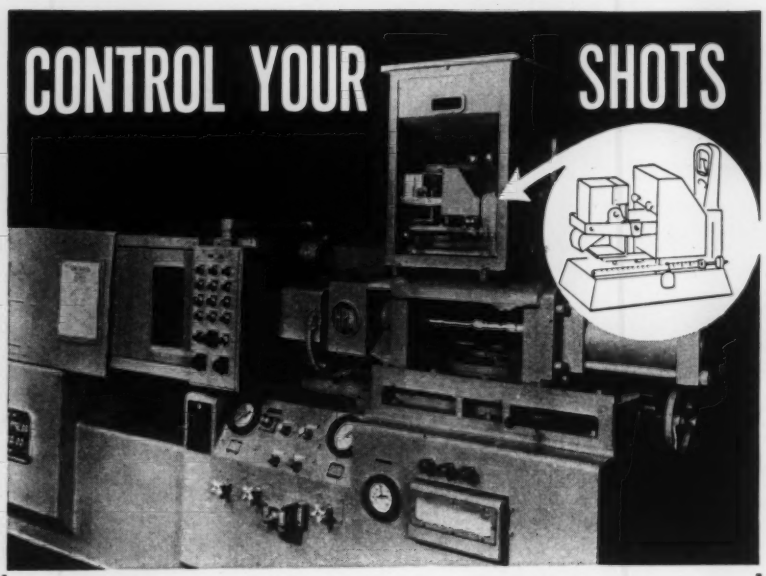
FLUID MOTOR
Vane Type
50 to 3500 rpm
Pressures to 1500 psi

RESERVOIR
With Control Panel
Designed to your space
and circuit requirements

RACINE
NFPA NATIONAL FLUID POWER ASSOCIATION

RACINE HYDRAULICS & MACHINERY, INC.
2073 Albert Street
RACINE, WISCONSIN, U. S. A.

—ITEM 600—



EXACT WEIGHT Weigh Feeders now offered on HPM injection machines

These weigh feeders, developed by Exact Weight for HPM Plastics Injection Molding Machines, provide more accurate measurement than is possible with volumetric feed. Each charge is accurately weighed and automatically delivered to the machine. Short and flash shots are prevented and rejects are eliminated or greatly reduced.

This is another example of how EXACT WEIGHT scales are being utilized in modern machinery design. Their value on milling machines to automatically weigh, balance, pre-set the machine and check the finished product, has been thoroughly proved. Installed as original equipment, they control the accuracy of high-speed filling and processing machines. EXACT WEIGHT scales can be easily incorporated into the design of any machine or product that requires accurately controlled weight as part of its function or manufacture.

Complete engineering data is available to designers. Write for free Form #3305 to help you do a better job.

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The Engineer's Library

papers presented at the eleventh annual conference held in Chicago in October, 1955. The papers are grouped under subject headings which include audio and acoustics, transistor and magnetic amplifiers, instruments and measurements, computers and computer elements, transistor applications, radar and navigation, servomechanisms and control.

Manufacturers' Publications

The Corrosion of Wrought Aluminum Alloys. *By M. J. Pryor, research metallurgist, Kaiser Aluminum & Chemical Corp.; 72 pages, 8½ by 11 in., paperbound; published by and available from Kaiser Aluminum & Chemical Corp., Consumer Service Div., PR-956, 1924 Broadway, Oakland 12, Calif.*

Summarizing recent field experience and the result of fundamental research studies, this booklet covers aspects of the corrosion resistance of aluminum under the following headings: fundamentals and typical forms of aluminum corrosion, the effect of alloy additions, corrosion behavior of wrought aluminum alloys, useful applications of aluminum alloys, factors accelerating corrosion, control of corrosion by design, and protective measures for aluminum exposed to severe corrosion conditions.

Government Publications

Bibliography on Shells and Shell-Like Structures, PB 111961. *Prepared by William A. Nash, David Taylor Model Basin, U. S. Navy; 74 pages, 8 by 10½ in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $2.00 per copy.*

Prepared for the general use of designers of structures similar to submarines and rockets, this bibliography includes recent references originated as a result of current submarine designs. Approximately 1450 papers and books are listed in chronological order to December, 1953.

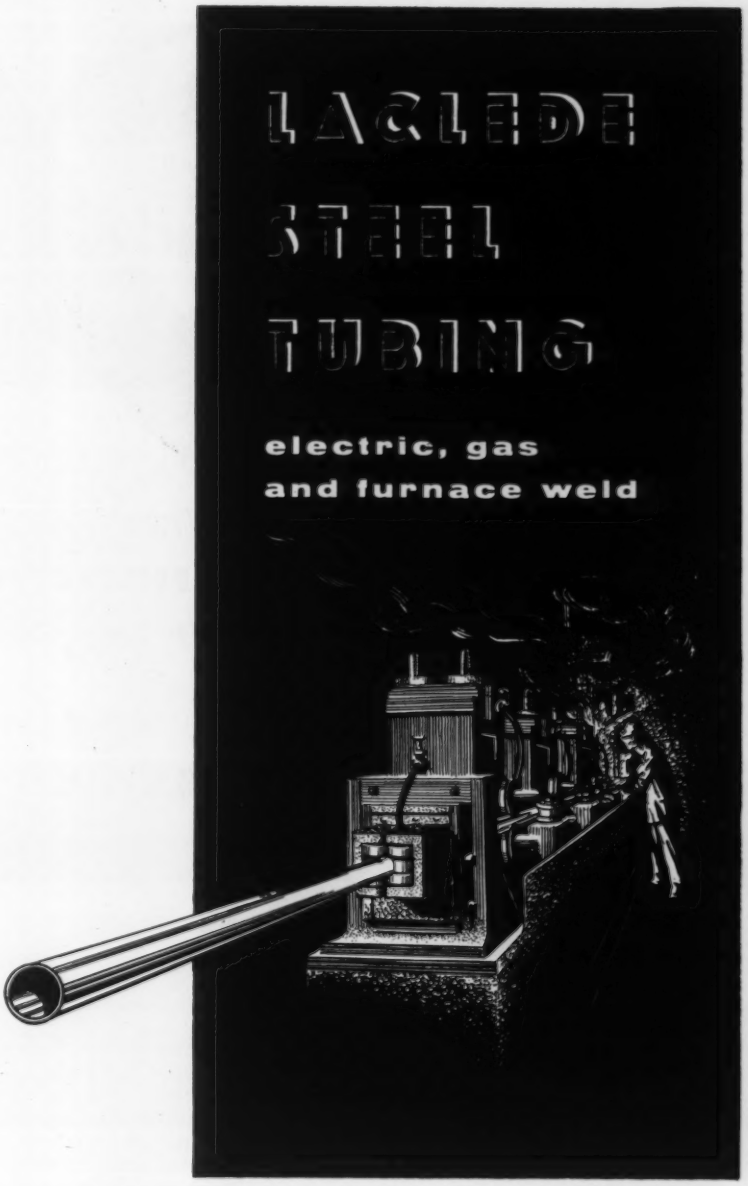
New Machines

Metalworking

Extrusion Press: New 1250/1500-ton aluminum extrusion press makes possible high-speed extrusion of 24-in. long aluminum billets with diameters of 5 or 6 in. at a rate of over 50 billets per hour. The unit incorporates an electro-hydraulic control which provides for immediate selection of three different operating cycles — manual, automatic control for dies requiring butt shearing, and automatic control for self-cleaning or bridge-type dies. On both automatic cycles the entire cycle pattern, including extrusion speed, can be preset in a short time and followed during a production run at a constant rate of operation. Preset extrusion speed can be varied during the cycle. *Sutton Engineering Co., Pittsburgh.*

Cut-Off Machine: Latest addition to the Light-Heavyweight line of cut-off machines is available for use with a dry-cutting abrasive wheel for cutting rod, bar and tubing stock, and can also be used with high-speed saw blades and conventional wood-cutting blades. The machine accommodates abrasive wheels and saw blades up to 12 in. in diameter. Blades or wheels are guarded by a heavy cast-iron guard. Totally enclosed motor is 3 hp, 220/440 v, 3 phase, and is fan cooled. It has an overload capacity up to 7 hp. Air-feed attachment and automatic spray coolant system are available. *Walker-Turner Inc., Plainfield, N. J.*

Surface Grinders: Redesigned Models 24 and 36 vertical rotary surface grinders increase stock removal rates and accommodate work requiring close tolerances. Continuous downfeed system increases range of feeds. Redesigned base is strong and rigid, with additional cross girths. Coolant tank is separate from the machine so that changes in coolant temperature will not affect the accuracy of the



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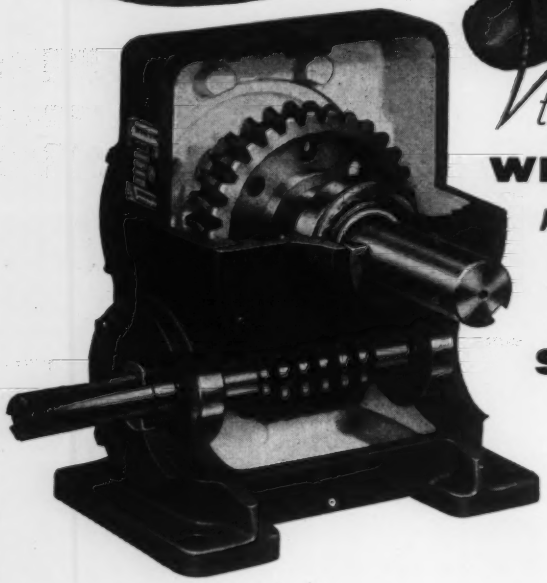
QUALITY CONTROLLED
STEEL
to produce the best
in manufactured
products

LACLEDE STEEL COMPANY
SAINT LOUIS, MISSOURI

—ITEM 602—

HERE'S THE ANSWER
to greater performance for
your speed reducer dollar!



the New
WINSMITH
"C"
SERIES

Something NEW has been added to Winsmith speed reducers...it's the new "C" Series with five new features that make every reducer in the line your best dollar for dollar buy. Both input and output shafts are larger and stronger, larger tapered roller bearings are used throughout, contoured fins at base give secure, vibrationless mounting and housings are designed for greater heat radiating capacity. *Net result?* Greater performance, greater stamina, greater dependability.

The "C" Series is comprised of 108 models in both single and double reduction units—there is a unit to meet every speed reducer need—*with greater value for your horsepower dollar.*

WINSMITH
SPEED REDUCERS

GET THE FACTS:
on the complete "C" Series...write for Winsmith's new catalog. Contains complete engineering selection information for each reducer described.

WINSMITH, INC. 16 Elton Street, Springville, (Erie County), N. Y.

—ITEM 603—
For More Information Circle Item Number on Yellow Card—page 19

New Machines

machine. Bellows-type guard protects the upper Vee and flat ways of the column, and a telescoping steel guard protects the lower column ways. Carriage extends inside the column and its ways completely cover the bed ways. Two spindle drive systems are available on the grinders. One is standard built-in drive with semi-enclosed motor, the other a coupling-type drive with standard TEFC motor which meets JIC standards. Model 24 has a 30-in. magnetic chuck, 18-in. segmented wheel and 40-hp motor. Model 36 has a 36-in. magnetic chuck, 18-in. wheel and 50-hp spindle motor. Automatic cycling is available on both machines at additional cost. *Mattison Machine Works, Rockford, Ill.*

Air Press: Bench-mounted unit is designed for spring manufacturing including looping, bending and coiling wire up to 3/32-in. diam. It can also be used for light punching, trimming, crimping and secondary operations at high speeds. Over 1800 loops and 300 stampings per hour can be made. The press is equipped with bolster plate, foot switch, solenoid valves and all connections. Screw stop adjusts ram stroke up to 2 in. and a valve controls ram speed. The machine is 10 x 10 x 18 in. high and has a 6-in. opening. *Carlson Co., New York.*

Face Grinder: Improved 18-in. model incorporates a motorized spindle, eliminating pulleys and belts. It is equipped with a 15-hp, 900-rpm heavy-duty motor. Box-type construction provides maximum rigidity for accuracy in grinding any flat or square surface and provides large bearing surfaces. The cup-shaped 18-in. grinding wheel is mounted perpendicular to the table. The unit will face grind cold or hot-rolled steel, tool steels, steel castings and all nonferrous alloys. When used for grinding castings, it eliminates all milling or planing. *Abrasive Machine Tool Co., East Providence, R. I.*

Packaging

Weighing Machine: Automatic net weighing unit incorporates precision industrial scale with visual

indicator, net weigh hopper, automatic cutoff controls and materials handling equipment. Over-under indicator for visual checking eliminates the need for separate checkweighing. Calibrated adjustments with counterweights of known value, graduated beam, and poise and scale indicator make the machine particularly useful for packaging, sacking or batching. Two rates of feed are each adjustable to provide bulk and dribble feeds. The unit has a fast responding lever system and weigh hopper discharge. It is available in two models, one with capacity to handle products weighing up to 3 lb and the other, from 3 to 10 lb. *Exact Weight Scale Co., Columbus, O.*

Wire Stitcher: OG portable unit makes approximately 200 stitches per minute on either single or double fluted board, fiber, wood or leather. It uses 0.103 x 0.020, or finer, ribbon wire and accommodates a 5-lb spool at one time. Filled or partially filled cartons can be used. The machine can be adapted to tacking with 0.020 x 0.030 wire or wire of other dimensions. *Ordnance Gauge Co., Philadelphia.*

Processing

Blast Cleaning Machine: Super Tumblast batch-type airless abrasive blast cleaning machine cleans sand, scale, oxides and other contaminants from work that can withstand tumbling action. It has an operating load capacity of 28 cu ft. The blast unit throws 830 lb of abrasive per minute, making it possible for the cleaner to employ only one abrasive hurling wheel. A separator, mounted at the bottom of the machine, separates and removes sand and contaminants from the abrasive mixture and provides optimum mixture throughout the blast cycle. Power-operated door is sealed and rigidly reinforced to keep abrasive from escaping the machine. It withstands impact from both inside and outside and travels in tracks integral with the side frames of the machine. The unit can be automated, with a push-button actuating the full sequence

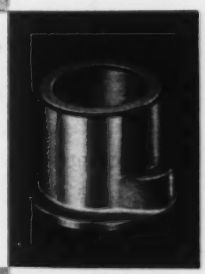
time to re-examine

BEARING APPLICATIONS

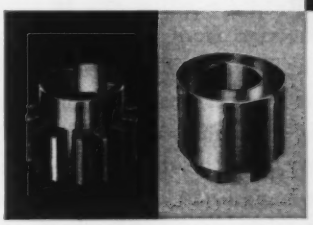
Striking cost reductions in bearing applications in many mechanical products are made possible by the use of Bunting Sintered Powdered Metal Bearings and parts.

Bunting engineering counsel can guide you in the selection of designs and alloys that will provide bearings of exactly the type, design and material that will fully meet both cost and functional requirements, whether the material be Cast Bronze or Sintered Metal.

A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command comprehensive data and facts based on wide experience in the designing and use of cast bronze and Sintered Powdered Metal Bearings and parts.



Write to our Product Engineering Department in Toledo or consult our nearest Sales Engineer.



Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

—ITEM 604—

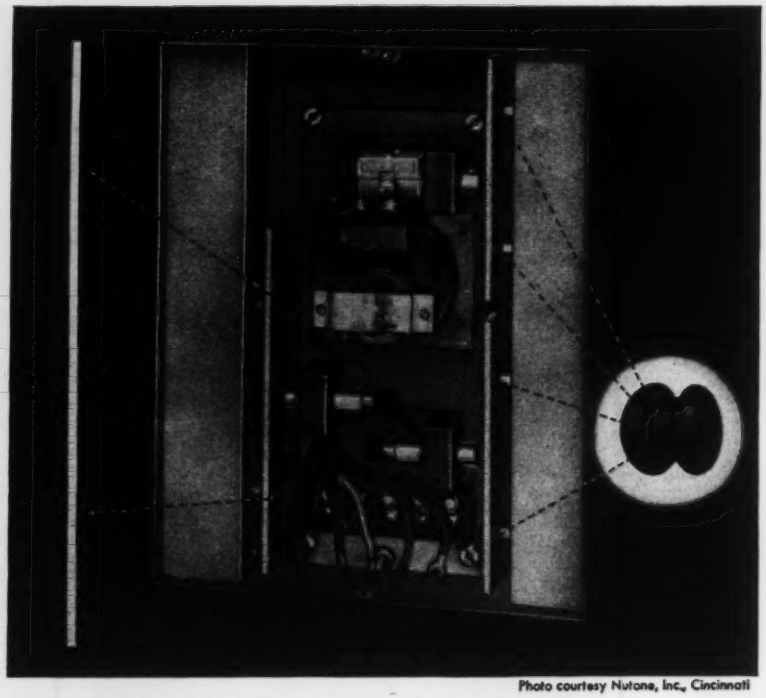


Photo courtesy Nutone, Inc., Cincinnati

Engineers Develop New Use for Rubber

Rubber, normally used to *reduce* vibration, now can be made to *increase* vibration

Here rubber grommets serve as mountings for the tone bars in Nutone Door Chimes. To obtain maximum tone quality and resonance required of these musical chimes, the grommets must vibrate compatibly with the tone bars . . . a truly *unusual assignment* for rubber.

Only by skillful compounding can rubber be diverted from its normal dampening characteristic and be given this vibrant quality. The slightest deadening effect would destroy the rich tones and kill the tone hang.

The successful development of this lively, age-resistant rubber stock typifies the complete engineering and laboratory—as well as manufacturing—skill available at Continental. Whenever you need "engineered rubber parts" — molded or extruded, natural or synthetic—call Continental, Specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

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engineered by **CONTINENTAL**

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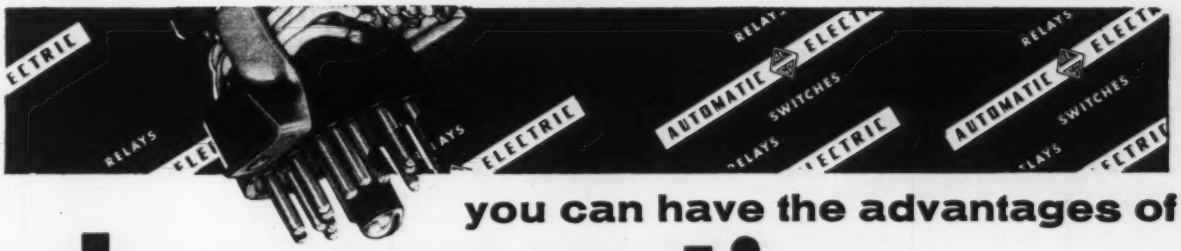
New Machines

from loading to unloading. Design also incorporates redesigned blades, strain-free blade holding device, easily accessible wheel guard housing and revised wheel guard liners. *Wheelabrator Corp., Mishawaka, Ind.*

Snap Hearth Furnace: Suspended hearth-type furnace for heat treating and quenching of small parts has radiant tube heating. Suction type radiant tubes prevent contamination of prepared atmosphere. Operating temperature range of 1400 to 1700 F makes the furnace applicable for clean hardening, dry cyaniding and carbon restoration. Net heating rate of the furnace is up to 300 lb per hr at 1600 F, depending upon size of parts, kind of steel used and type of treatment. Two types of standard atmosphere generators are available, one producing an endothermic and the other an exothermic atmosphere. *Surface Combustion Corp., Toledo, O.*

Cleaning Machine: Roll-O-Matic Metal Laundry automatically washes, rinses, rust-protects and dries small metal parts such as acorn nuts, screw machine parts and fittings. Parts to be treated are loaded into a revolving drum attached to an air cylinder and lowered into the tank. They are rotated in the wash solution for a predetermined period, followed by a spray rinse, rotating antirust treatment and a hot air dry. Washing and antirusting solutions are salvaged for reuse. The unit is manufactured to accomplish as many chemical or liquid stages as required. *Magnus Chemical Co. Inc., Equipment Div., Garwood, N. J.*

Soldering Unit: Sonobond Model S-O-H-55-12 is designed for the ultrasonic fluxless soldering of small electronic parts such as transistors. The unit is extremely small and easy to handle, and has tips which are readily changeable to other standard or special tips by screw connection. Diameter of the tips varies from 1/8 to 0.020-in. or less. Unit tins silicon and germanium as well as a variety of nonferrous metals. *Aeroprojects Inc., West Chester, Pa.*



you can have the advantages of

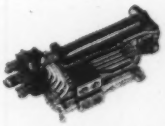
plug mounting

in all these Automatic Electric

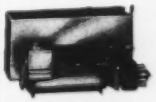
relays

CLASS A:
The "all-purpose" relay for use where first cost is important. Gives long, dependable service. Size: 4⅜" x 2⅛" x 1⅞".

CLASS B:
Made for extremes of long service life and dependability — often exceeding 400 million operations! Size: 4⅜" x 2¼" x 1¼".



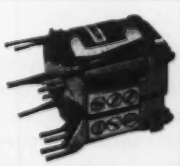
CLASS F:
Low operating power makes this relay especially desirable in a.c. circuits where relays function without specified operate or release time delays. Size: 4⅝" x 1¹⁵⁄₁₆" x 1¼".



CLASS S:
Made for exacting miniature requirements. Used in aircraft where resistance to shock and vibration is needed in a small, light, reliable relay. (For printed circuit applications—see below.) Size: 2⅛" x 2" x 1¼".

CLASS Z:
Provides maximum timing in a "small-as-possible," low-cost relay. Compact, light, resistant to shock and vibration. Size: 3¼" x 2⅞" x 1¹³⁄₃₂".

"PLUG-IN" RELAY FOR PRINTED CIRCUITS.
Design of coil and spring terminals permits direct insertion into printed circuits with high-conductance connections, easily soldered. Bearing design gives up to 120 million operations without readjustment or relubrication. Size: 1¾" x 1⅛"-1¾" (depending upon number of contact springs) x 1".



For any application, you can choose an Automatic Electric relay—a top-quality relay in every way—with the additional advantages of *plug mounting:*

Minimized inventory—When you standardize on plug-in relays, you can often interchange the same basic relay in many models of your equipment. Thus, you make substantial savings by reducing your inventory costs, speeding assembly.

Fast, simplified inspection and maintenance—Plug-in relays permit periodic bench inspections with almost no "down time" involved. Entire banks of relays can be removed for testing, and then replaced, in *seconds.*

Simplified replacement—Plug-mounted relays can be replaced quickly and easily at otherwise inaccessible points in your equipment. Even an unskilled service man can replace relays in a matter of seconds without tampering with circuit wiring.

You can select Automatic Electric plug-in relays from five basic types and thousands of individual assemblies.

Send for Relay Circulars 1800—1804—They give complete specifications, dimensional drawings, and helpful information. *Address* Automatic Electric Sales Corporation, 1033 West Van Buren Street, (HAymarket 1-4300) Chicago 7, Illinois. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

AUTOMATIC ELECTRIC

Originators of the dial telephone • Pioneers in automatic control

GENERAL TELEPHONE SYSTEM

—ITEM 606—

Parts and service supplied by more than 2200 dealers in the United States, Canada and in 82 foreign lands

In addition, traveling service clinics enable dealers and their mechanics to keep up to date on latest industry practices and on Wisconsin service techniques . . . including complete instructions on preventive maintenance to keep Wisconsin engines operating at top efficiency year after year . . . indefinitely.

Just a couple of more good reasons why it pays to specify Wisconsin Heavy-Duty Air-Cooled Engines for your equipment... service-proved, performance-proved and climate-proved wherever engine-powered equipment is used.

Write for Engine Specifications Bulletin S-188, and a copy of our complete list of approved service stations throughout the world.

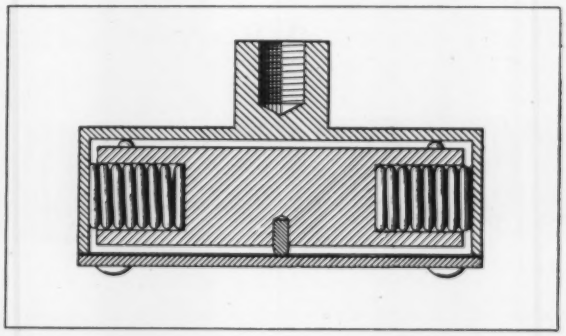
WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

—ITEM 607—
For More Information Circle Item Number on Yellow Card—page 19

NOTEWORTHY Patents

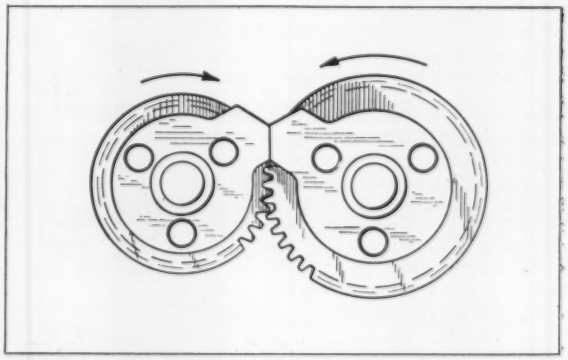
Vibration Damper

Amplitudes of linear vibration over a substantial frequency range are reduced by a tuned vibration damper. Action of a rectangular inertia mass, supported in the damper housing by preloaded springs, absorbs vibration energy at the tuned frequency of the spring-mass system. Pumping action, choked flow and viscous drag of a silicone oil that fills the gaps between inertia mass and housing extend the frequency of effective damping over a range bracketing the resonant value. *Patent* 2,736,393 *assigned to Houdaille-Hershey Corp., by Bernard E. O'Connor.*



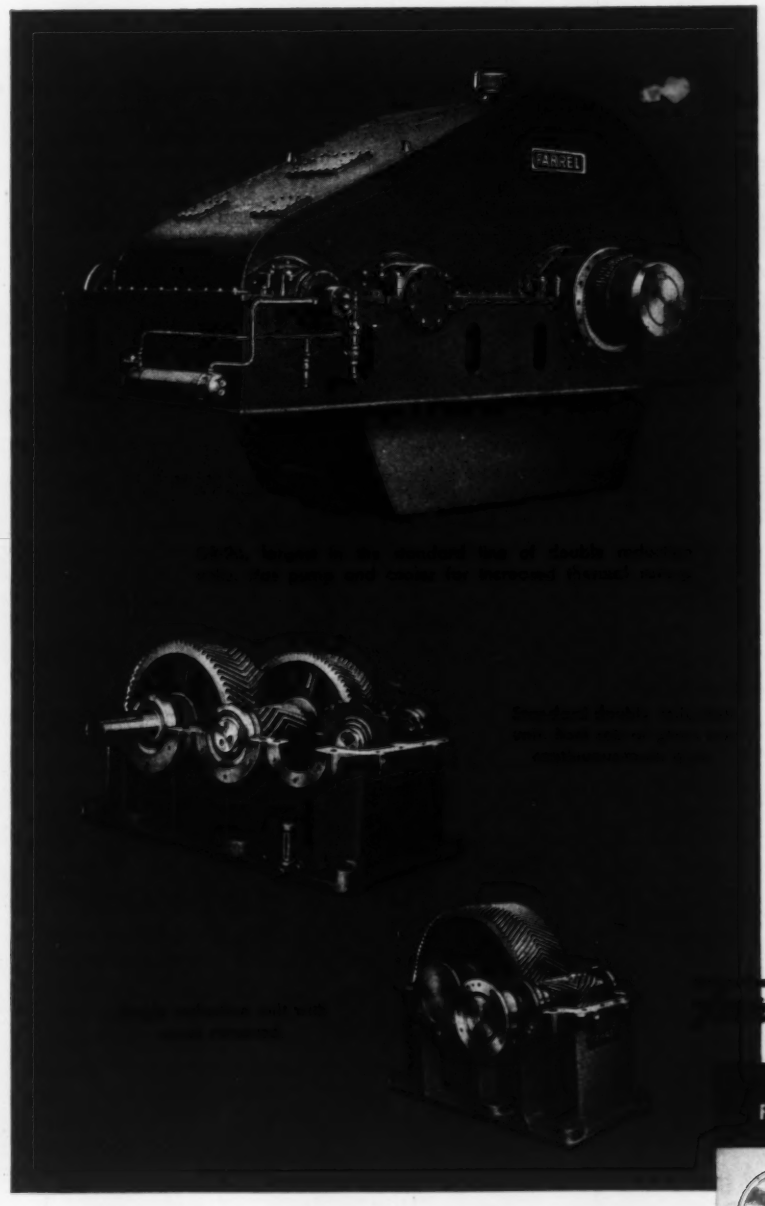
Rotational Stop Mechanism

Predetermined rotational limits greater than 360 deg are established for meshed gear pairs by a differential stop mechanism of high-torque capacity. Applicable for adjacent gears proportioned at other than integral ratios, the flat-plate stops can be fixed to idler pairs or employed directly in a gear train. Engaged-stop position of gear pair illustrated, wherein a 48-tooth gear meshes with a 41-tooth gear,



MEET YOUR NEEDS

from Farrel's new, broader line of speed reducers



new sizes available in heavy-duty and light-type units

Farrel® speed reducers have long been preferred for their ability to meet unusual and exacting requirements. Now, the complete line has been re-engineered, rerated and expanded to extend the recognized advantages of the units to additional applications and fields.

Both heavy-duty and light-type units are available in a broader range of sizes, and in a series of standard ratios as follows: *Single reduction* — from 1½:1 to 10:1; *double reduction* —from 10:1 to 70:1; *triple reduction*— from 83.9:1 to 323:1. Special designs are also available, including speed-change units having two or more selective speeds and drives to meet special requirements.

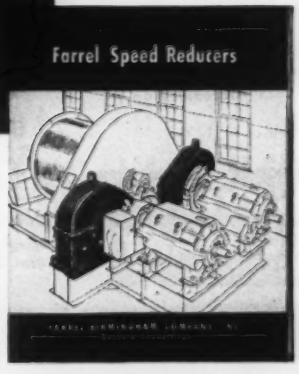
Farrel speed reducers incorporate a number of important improvements. These result from a continuing research program, and from experience gained in the application of gear units to the many types of machines manufactured by the company.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.

Sales Offices: Ansonia, Buffalo, New York, Boston, Akron, Detroit, Chicago, Minneapolis, Fayetteville (N. C.), Los Angeles, Salt Lake City, Tulsa, Houston

Farrel-Birmingham®



THIS FREE BOOKLET gives complete details of the full line of Farrel speed reducers. It includes specifications, horsepower rating tables, overhung load capacities, dimensions and weights. Send for your copy today.

FB-1080

Does your problem involve efficient movement of air? Garden City can help you. For over 75 years they have maintained leadership in the industrial fan field. Three of the many reasons for their superiority: heavier construction, more advanced design, lower maintenance cost. Garden City's high temperature fans (850 to 1650°) are constructed of finest heavy gauge nickel-alloy steels. The radial, forward and backward curved wheels are abrasion and corrosion resistant to a high degree.

Garden City's air cooled shafts on their heat fans increase bearing life. Consequently, the bearings remain maintenance-free longer.

Send your O.E.M. specifications to Garden City's engineers. Their experience may be of help.

Write today for free brochure giving full information.

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Representatives in Principal Cities

• Fans for Industry • Backward Curve • Forward Curve
• Material Handling • Radial Bladed • Small Exhaust

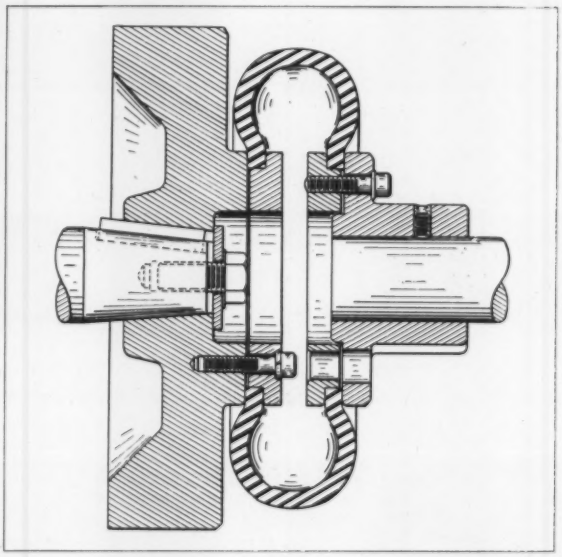
—ITEM 609—

Noteworthy Patents

repeats after 2100-deg reversed rotation of the larger gear. Mechanism is suitable for use with simple spur gears, bevel gears, or with friction-driven pulleys. *Patent 2,744,416 assigned to Avien-Knickerbocker Inc. by Leon Feigin.*

Flexible Coupling

Torque fluctuations transmitted from driving to driven shafts are reduced by a flexible coupling that employs an annular resilient member between coupling halves. Besides the flexing member, which can be a small synthetic-rubber tire casing, the coupling



employs a small flywheel bolted to the driven coupling member as a means for absorbing torque and speed pulsations. In a modification of the basic unit, the annular casing is filled with a viscous damping liquid for additional kinetic damping. *Patent 2,747,386 assigned to Carrier Corp. by Robert W. Ayling.*

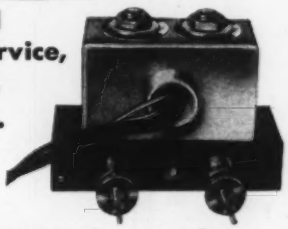
Pneumatic time-delay fuse, for use with air-operated equipment requiring intermittent surges of air for relatively short durations, closes automatically if specified flow rate is exceeded or if flow persists beyond desired interval. Time-delay feature is adjustable. *Patent 2,748,797 assigned to Specialties Development Corp. by Edward J. Heizer and Wallis C. Art.*

Screw actuator employs overruning ratchet clutches to stop linear motion of actuator body at preset limits. Clutches, which transfer rotary motion of actuator screw to drive nut, disengage when nut assembly strikes adjustable limit-stop collars. Clicking sound of disengaged ratchets provide limit-of-movement signal. *Patent 2,743,623 assigned to Lambert Engineering Co. by Willis L. Wells.*

Modernair

NEW 1/4" SOLENOID VALVE

for Air or Oil Hydraulic Service, 30 to 150 p.s.i.



★ ULTRA COMPACT...only 4-9/16" long, 3-5/16" high, 1-3/4" wide overall!

★ NON-CORROSIVE CONSTRUCTION... brass and aluminum throughout.

★ "O" RING SEALS... replaceable without disturbing piping.

★ AVAILABLE IN SINGLE OR DOUBLE SOLENOID for all popular a.c. or d.c. voltages.

★ 3-WAY (3 port) OR 4-Way (5-port) MODELS, with or without exhaust speed control valves as shown. Standard ports are female 1/4" NPT.

MODERNAIR's new BV Series 1/4" solenoids put the answer to scores of fluid power control problems literally in the palm of your hand. Why not get the facts now? Write or wire for specifications, prices.

Modernair Trademark CORPORATION

Dept. E-8, 400 PREDA ST., SAN LEANDRO, CALIF.

Member National Fluid Power Association 20

—ITEM 610—

ZENITH

MOST DEPENDABLE CONTACTORS IN THE INDUSTRY

For:

time switches—
motor starters—
lighting—equipment
control—all applications
requiring complete reliability and long service life.

All parts are accessible—readily inspected, easily replaced. Full floating armature permits perfect magnetic seating, silences AC hum.

Contacts are copper to copper. Heavy compression springs assure contact pressure, quick opening. Coil will not overheat in 24-hr. continuous service.

Zenith contactors are made for severe duty. Capacities to 400 amps.

Send for this handy new bulletin

See classified telephone directory for name of local distributor

ZENITH ELECTRIC CO.

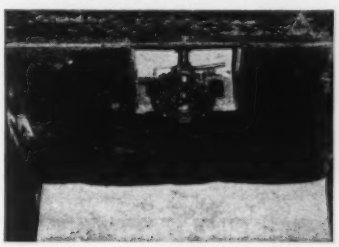
149 WEST WALTON STREET • CHICAGO 10, ILLINOIS

—ITEM 611—

ROCKFORD

Clutches Are Spin Strength Tested to Meet The Needs of Modern High Speed Engines

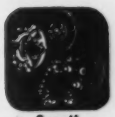
First they are put in a deep, armor-plated, concrete test pit.



Then fastened on a shaft that spins the clutch at high speed.

The clutch is spun, and highest R.P.M. recorded.

Let us help insure fully-tested clutches for YOUR products.


Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

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Clutch Division
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B. W. ENGINEERING MAKES IT WORK
ENGINEERING B-W PRODUCTION
B. W. PRODUCTION MAKES IT AVAILABLE

CLUTCHES

—ITEM 612—

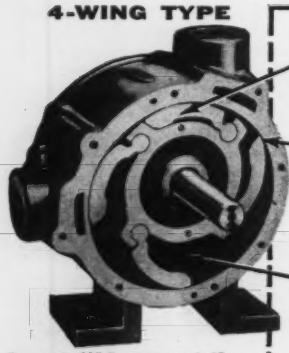
Exclusive Features of

LEIMAN Rotary Air and VACUUM PUMPS

bring you

★ High Vacuum
★ Greater Volume
★ Smaller Size
★ Lifetime Operation

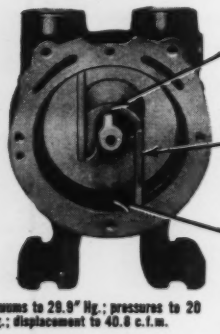
4-WING TYPE



- Curved Wings on easy-action hinge, maintain continuous wall contact.
- Cast Iron Wings and Cylinders hone themselves to hard, glassy smoothness—take up their own wear—assure leak-proof seal for years.
- Extra-large Air Space provides greater capacity, permits use of smaller pump.

Vacuums to 20" Hg.; pressures to 15 psig.; displacement to 162 c.f.m.

2-WING TYPE



- Automatic Wing Adjuster assures wing-to-wall contact, prevents sticking, guarantees positive action.
- Extra-long Steel Wings (not composition) provide long wear. Cylinder walls made of durable cast iron.
- Large air space provides more compact pump.

Vacuums to 29.9" Hg.; pressures to 20 psig.; displacement to 40.8 c.f.m.

Install LEIMAN AIR PUMPS

for dependable Vacuum (Suction) and Pressure

FREE ENGINEERING DATA

- *Application Book* showing 60 "how-to-do-it" blueprints of actual applications.
- *16-page Catalog* showing construction, types, sizes, capacities, etc.

Precision-made, compact Leiman Air Pumps have fewer moving parts — no tips or blades to renew — need no maintenance except occasional oiling — run for 10, 15 and 20 years without trouble or shutdown. Over half a million installed. Consult our engineers on any air application.

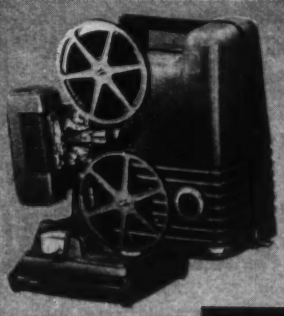
SEE OUR CATALOG IN SWEETS FILE

LEIMAN BROS., Inc.

148 Christie St., Newark 5, New Jersey

—ITEM 613—

ANOTHER FAMOUS NAME



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PHOENIX *Brush Holders*

BUYS

Because

Revere insists on finest quality for every camera component . . . the best assurance there is of continued customer satisfaction!

Send for Catalog 56L — shows how to order molded or assembled types.

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4211 West Lake Street — Chicago 24, Illinois

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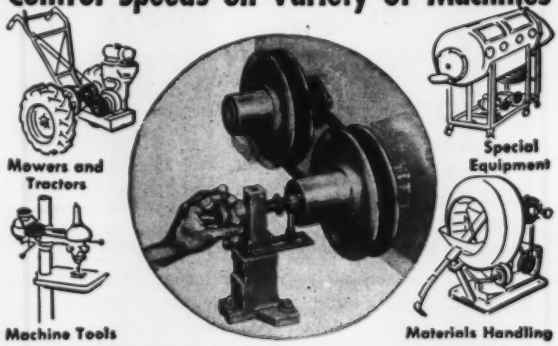
SPEED SELECTOR

VARIABLE PITCH SHEAVES

Control Speeds on Variety of Machines



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Special Equipment

Machine Tools

Materials Handling

New! Wide Speed Range! Low Cost Sheaves

Speed Selector Sheaves can give your machines or equipment extra wide-range speed control on fixed centers. Efficient, rugged, simple to use — low in cost! Write for Illustrated Bulletin.

CATALOG FREE! WRITE TODAY

SPEED SELECTOR INC.

120-B NOBLE COURT • CLEVELAND 13, OHIO

—ITEM 615—

For More Information Circle Item Number on Yellow Card—page 19

Meter-Relays, VHS Relays, Simplytrol and Versatrol Automatic Controls, Panel Meters and Indicating Pyrometers

40 PAGE ASSEMBLY PRODUCTS CATALOG 4-A

Contents include:

"Circuitry"—6 pages of diagrams and text, including response time tables and discussion on non-locking contacts.

Ordering information.

Prices and detailed specifications for:

Clear plastic, black bakelite and ruggedized-sealed styles of:
- Meter-relays
- Indicating meters
- Indicating pyrometers

VHS Relays

Plug-in relays, power supplies

Automatic pyrometers

Automatic control packages and components

Bearing monitors

Oven pyrometers and millivoltmeters

Kiln pyrometers

Shunts

Transformers

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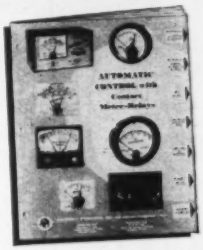
Assembly Products, Inc.
Chesterland 51, Ohio
HAmilton 3-4436
(West Coast: Desert Hot Springs 51, Calif. Phone 4-3133).

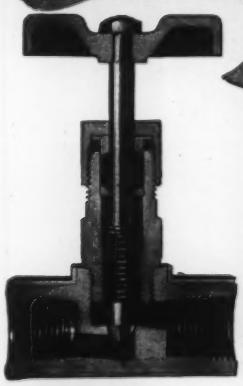


Meter-relays provide control of mechanical operations or chemical processes through alarm and automatic shut-off, or continuous on-off control. Applications include: Bearing temperature alarm and shut-off on pumps, turbines, generators. Automatic speed controls for machines and conveyors. Computer shut-off if power supply voltage varies. Warning and control in radiation measuring equipment and processes. Automatic switching of standby equipment in microwave communications. Continuous control of pH. Signal detection in radar warning systems.

See us at WESCON SHOW, Aug. 21-24, Los Angeles, Calif.

—ITEM 616—

Now... the Marsh Needle Valve in 416 Stainless Steel throughout!



All the superior dependability of the Marsh Needle Valve... with all the corrosion resistance and durability of 416 Stainless Steel! Guaranteed for working pressure up to 10,000 psi; equally efficient at any lower pressure. Globe and angle patterns with double female connections in ⅛" to 1" size range. Also globe and angle valves with male inlet, female outlet, ¼" and ½" sizes.

For complete details, write for Bulletin No. NV-2.

MARSH INSTRUMENT CO.
Sales Affiliate of Jas. P. Marsh Corp.
Dept. B, Skokie, Illinois

MARSH
"THE STANDARD OF ACCURACY"

Marsh Instrument & Valve Co. (Can.) Ltd., 8407 103rd St., Edmonton, Alta., Can.

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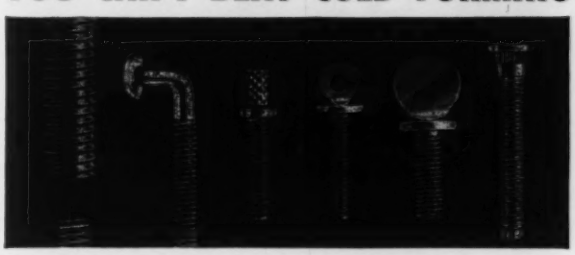
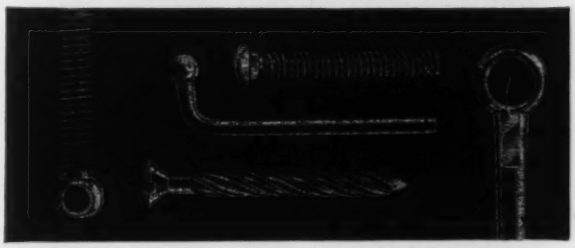
YOU CAN'T BEAT COLD FORMING



FOR PARTS LIKE THESE—AND



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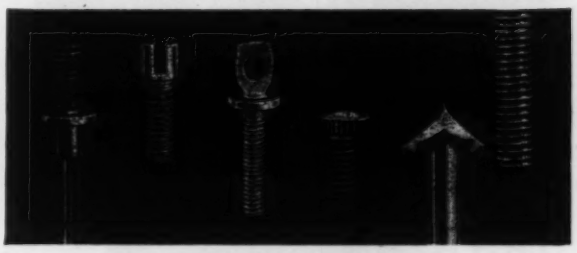

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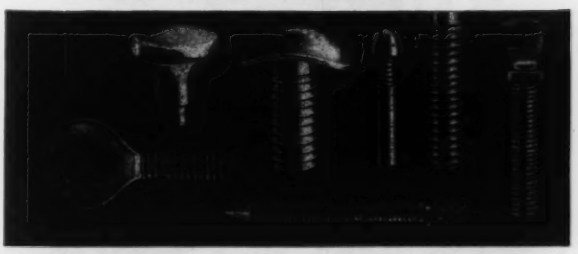
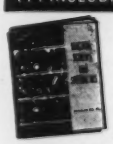


MACHINE SCREWS AND SPECIAL FASTENERS ARE OUR BUSINESS
... INCLUDING SQUARE AND HEXAGON MACHINE SCREW NUTS



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THE PROGRESSIVE MANUFACTURING COMPANY
DIVISION OF THE TORRINGTON COMPANY
52 Norwood St., Torrington, Conn.

—ITEM 618—

The most complete V-drive line. Thousands of stock size and bore combinations in single and multiple groove sheaves, variable pitch, die cast, pressed steel, cast iron. And the widest selection of V-belts—from FHP to steel cable, including Griplink, Griproll and new Poly-V. There's a Browning Gripbelt drive for your every job. Ask distributor or write us for *free catalog GC101.*

Browning MANUFACTURING COMPANY
MAYSVILLE, KENTUCKY

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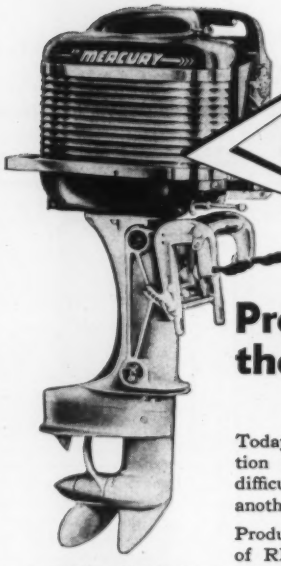

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Takes a Product out of the Look-alike Class

Today, products similar in function look so much alike it is difficult to tell one make from another.

Products made wholly or in part of RIGID-tex Metal take on a new, identifying beauty that is quickly recognized.

The cowling on the motor above is RIGID-tex Metal with customers own *exclusive* pattern.

RIGID-tex Metal can make your product distinctive and easily identified too!

RIGID-tex METAL IT'S RIGIDIZED

RIGIDIZED METALS CORPORATION
6938 Ohio Street Buffalo 2, N. Y.
Sales Representatives in Principal Cities

—ITEM 620—

Here's BIG HELP IN TERMINAL WIRING!

The correct wire to correct terminal every time!

The New
JONES FANNING STRIP

Connections are made through Fanning Strip, on bench or anywhere apart from barrier strip, and quickly slipped into assembly.

Designed for use with Jones Barrier Terminal Strips Nos. 141 and 142, for 1 to 20 terminals.

9-141 Barrier Strip

Simplifies and facilitates soldering. Insures positive correct connections. Saves time. Ideal for harness or cable assembly. Strong construction: Brass terminals, cadmium plated. Heavy bakelite mounting.

See New Developments at the WESCON Show — Booths 614-615

● 9-161 Fanning Strip. Pat. applied for.

Send for complete data on this new basic improvement!

Jones HOWARD B. JONES DIVISION

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FOR YOUR
FREE 1956 TEMPLATE CATALOG

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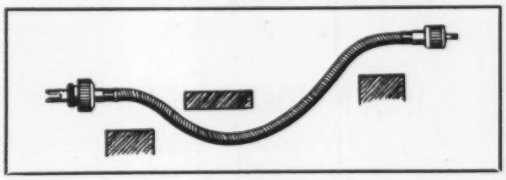
IN CANADA: ERICO INCORPORATED, 3571 Dundas St., West, Toronto 9, Ontario

—ITEM 622—

STRENGTH AND FLEXIBILITY



Recent advances in manufacturing techniques have made possible the production of flexible shafts able to handle loads greatly exceeding those of some years ago when flexible shafting was largely confined to the handling of small loads. This was due to the size of the flexible cable having to be enlarged excessively in ratio to the load applied.

For example, a flexible shaft which will carry a load of 55 lb. inches will require a flexible cable with a .187" diameter. This cable has a torsional deflection of only 4.7° and may be bent into a minimum radius of 3" while made to rotate in either a clockwise or counter clockwise direction when being viewed from the driven end. Previously, this same load of 55 lb. inches would have required a much more cumbersome and more expensive cable which would have lost its flexibility with the increase of the cable diameter.

Flexible shafting for use in industry offers distinct advantages in alignment, the main advantage being its ability to transmit power over, under and around obstacles without the use of costly and complicated gearing. It responds immediately to the drive power and may function in a continuous or intermittent operation. Flexible shafts may be composed of either power drive cable for rotation in either a clockwise or counter clockwise direction, or they may be composed of remote control cable which provides for rotation both clockwise and counter clockwise.

The F. W. Stewart Corporation is prepared to manufacture complete flexible shaft assemblies to your specifications which will permit easy and economical incorporation of flexible shafts into your designs.

Send for further details. F. W. Stewart Corporation, 4311—13 Ravenswood Avenue, Chicago 13, Illinois.

—ITEM 623—

THROUGHOUT INDUSTRY
THE **BEST BUILT**
MACHINES USE

Abart GEARS

custom cut by ABART to your specifications

- Any Type
- Any Quantity
- Any Gear Material
- 96 Pitch to 5/7 P. D.
- ¼" P. D. to 18" P. D.

Send B/P and specification or samples for quotations. No stocks.

ABART GEAR and MACHINE CO.

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—ITEM 624—

molded **COMMUTATORS**

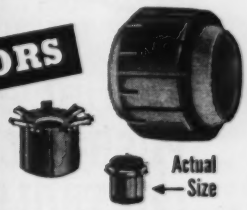
many types and sizes

supplied from stock

to help motor makers

build better motors

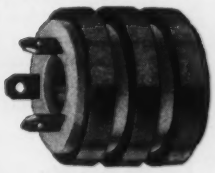
LARGE or SMALL



WITH or WITHOUT PRONGS

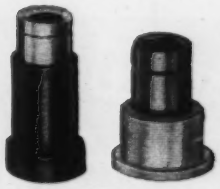
Many Stock Sizes

SLIP RING UNITS



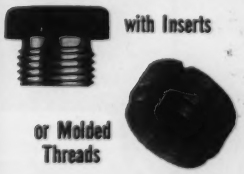
Custom Engineered

BRUSH HOLDERS?



NYLON or Phenolic

NEED BRUSH CAPS?



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Send Blueprint for Quotation

Midwest Molding
AND MANUFACTURING COMPANY

GURNEE
98
ILLINOIS

Chicago Phone: Dickens 2-0777
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PLASTICS · TOOLING · COMPRESSION · INJECTION

—ITEM 625—

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PUSH-PULL REMOTE CONTROLS

40-page Illustrated Remote Control Catalog

Here is a valuable technical guide that can give you important background information toward solving your remote control problems. The various basic flexible and rigid control combinations, locking devices, fittings, etc., are shown together with information on the custom manufacturing of controls to your specifications.

Write Today

ARENS CONTROLS, INC.
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Engineer, M. E.

INDEPENDENT THINKER MECHANICAL DESIGN

New methods requiring independent thinking and development are expected of an engineer with 5 years of mechanical design experience.

Produce sound, advanced mechanical designs, provide technical directions with manufacturing where new techniques are required; plus design contacts and liaison; perform tests on materials; provide assistance to other units.

Live in a forward-looking city of Pittsfield, Mass. in the heart of the Berkshire vacationland, and work for a forward-looking company. . .General Electric's Naval Ordnance Department, where you get professional recognition along with numerous benefits that make GE known throughout industry as a "good place to work."

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Naval Ordnance Department

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Let our engineers with more than a decade in gear experience show you how Nylon Gears can save you money – let us consider your gear problems during the design process – send blueprints or specs for prompt estimates.

104

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4608 W. Fullerton • Chicago 39, Illinois

—ITEM 628—

ENGINEERS
AVAILABLE OR WANTED

AVAILABLE: Mechanical design engineer, experienced and competent, available for projects and limited engagements. Over twenty years of experience on drafting, design, development—production tools, power press dies, machinery, product. Address Boxholder 202, Back Bay Postal Annex, Boston, Massachusetts.

WANTED: Mechanical Engineer. For process development and equipment design including automatism of new method for metal removal. An excellent opportunity for the right man to grow with a young, aggressive, and rapidly expanding firm. Send brief resume of education and experience. Address Box 906, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

WANTED: Engineers—Electrical and Mechanical. Our positions offer an opportunity within the fields of Atomic Power and Automation. If you have experience in Mechanical Design, Heat Transfer Servo Mechanisms, Stress Analysis, Electrol-Mechanical Devices and have the ingenuity and initiative for applying your experience, we have choice positions in New Product Development. Become associated with a growing far-sighted Company, long established in the manufacture of motors, generators and control devices. Address H. Y. Reeves, Reliance Electric and Engineering Company, 1088 Ivanhoe Road, Cleveland 10, Ohio.

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—ITEM 629—

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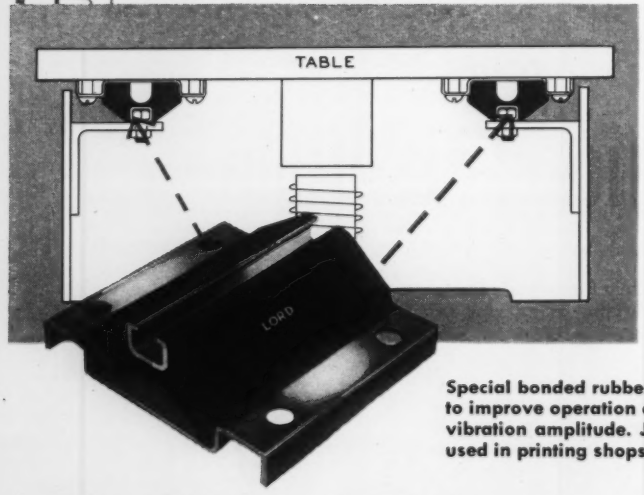
gives paper jogger greater amplitude with less power input



Vibration, usually an undesirable effect to be minimized, can also be converted into useful work. This requires precise control for maximum effectiveness.

An example of this is the electromagnetic pulsations used by the Syntron Company on its PJ-15 and CPJ-15 Paper Joggers. LORD bonded rubber channel mountings control these vibrations, increasing their amplitude and producing more effective operation with less power consumption.

To provide uniform table motion and give the desired amplitude at the required frequency, the dynamic stiffness of the two LORD mountings must be closely controlled. These mountings, designed and produced to meet Syntron's strict requirements, are typical of the results when LORD engineering is applied to your vibration problem. LORD's experience in Engineered Vibration Control and Bonded Rubber Products is unsurpassed. Contact your nearest LORD Field Engineer or the Home Office, Erie, Pennsylvania.

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—ITEM 630—
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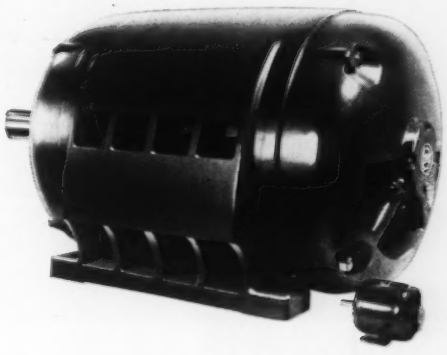

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Dayton 1, Ohio

—ITEM 503—

MASTER ELECTRIC MOTORS